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GEOMETRIC DESIGN STANDARDS FOR URBAN ROADS AND STREETS

(First Revision)

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1 INTRODUCTION

Geometric Design Standards for Urban Roads in Plains was first published by IRC in 1983. The goal of urban roads and streets design process is to create safe, comfortable and convenient access for all road users, promote environmental sustainability, while creating vibrant and liveable public spaces. These standards are adopted by local bodies and other urban agencies for roads in sub-urban areas. In recent past, lot of changes have taken place in the composition of urban traffic, volume of traffic, operating speed, pedestrian and NMT facilities, mobility, safety and ecology. The Urban Roads and Streets Committee (H-8) during the tenure 2015-17 decided to revise the document in order to keep pace with all changes in urban scenario and traffic demand. Accordingly, a sub-group was formed under the convenorship of Dr. Ch. Ravi Sekhar comprising Prof. M. Parida, Sh. D.P. Gupta, Shri Amit Bhatt, Shri Ahok Bhattacharjee, Dr. Shreya Gadepalli and Ms. Sonal Shah to prepare the revise document. This code provides standards on the geometric design of urban roads so as to provide balance allocation of road space for pedestrians, cyclists and public and transport users, thereby promoting and prioritizing accessibility over mobility The draft prepared by the sub-group was discussed in numerous meetings of H-8 Committee and finally approved in its meeting held on 18.08.2017 for placing before the HSS Committee.

The composition of the H-8 Committee is given below:

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Secretary General, Indian Roads Congress	Nirmal, Sanjay Kumar

The Highways Specifications & Standards Committee (HSS) considered and approved the draft document in its meeting held on 24th October, 2017. The inputs were also received from officers of S&R Zone of Ministry of Road Transport and Highways. The Executive Committee in its meeting held on 2nd November, 2017 considered and approved the same document for placing it before the Council. The Council in its 213th meeting held at Bengaluru on 3rd November, 2017 considered and approved the draft for printing.

The geometric design of urban roads shall follow the principles given below:

- **Accessibility:** People should be able to move safely and seamlessly through the city.
- **Safety and Comfort:** Streets are safe, clean and walk able.
- **Ecology:** Streets are climate resilient and impact on the natural environment is minimized.
- **Social Concerns:** Streets cater to the access needs of local communities, elderly and persons with disabilities.

Geometric design is influenced by a number of factors such as modal shares, nature of terrain, type, composition and volume of traffic, operating speed, and land use characteristics, integrated factors (mobility, safety and ecology). Geometric design for urban transportation facilities includes the following visible elements.

- Horizontal Alignment
- Vertical Alignment
- Cross Sectional Elements
- Intersections and Interchanges
- Essential Components
  - ♦ Pedestrian Side Walks and Crossings
  - ♦ Non Motorized Traffic (NMT)
  - ♦ Inclusive facility for persons with disability, elderly.

The concepts of mobility, accessibility, safety and ecology have been incorporated in the manual in view of increasing urbanisation. Mobility is the fast, safe and convenient movement of maximum number of people through the city. Providing safety and comfort is making streets safe, clean, walk-able by creating climate sensitive design. Consideration of ecology in highway design reduces impact on the natural environment; and reduces pressure on built infrastructure.

These geometric design standards are applicable to urban roads and streets in plain, rolling and hilly terrains. The terrain is classified based on the general class slope of the country across

the alignment. Terrain is classified as plain, rolling, mountainous and steep as per the criteria percent cross slope of the country given in IRC:73. All the main elements of geometric design for urban roads are included in the text. The layout of intersections and interchanges is not covered as standards for the same are brought out separately.

2 CLASSIFICATION OF URBAN ROADS AND STREETS

The following six classes of urban roads and streets have been recommended in the IRC Manual on Planning and Development of Urban Roads and Streets.

- Urban Expressway
- Arterial Road
- Sub Arterial Road
- Collector Street
- Local Street
- Non-Motorized Transport (NMT) Streets and Greenways

2.1 Definitions

- **Urban Expressway:** An urban expressway is an urban arterial highway for high speed regional passenger and goods traffic from inter-city highways/ expressways to connect to other inter-city highways entering the city at specific locations. These are full access control and having divided carriageways for high speed travel provided generally with grade separators at intersections and service roads on both sides.
- **Arterial Road:** A general term denoting a road/street primarily for through traffic, usually on a continuous route. Arterial roads facilitate mobility across the city and connect to long distance destinations within/outside the city, while providing safe NMT facilities. On-street parking shall be prohibited or restricted, except when there is space available for a service lane with parking. Safety for pedestrians will be ensured by providing segregated at-grade level.
- **Sub Arterial Road:** A general term denoting a road/street primarily for through traffic usually on a continuous route but offering somewhat lower level of traffic mobility than the arterial road. These are larger collector streets meant for movement through neighborhoods and to connect to arterial roads.
- **Collector Street:** A Street for collecting and distributing traffic from and to local streets and also for providing access to arterial/sub arterial roads. They shall be designed with dedicated footpaths. Various speed reduction measures will be employed to limit vehicle speeds to less than 40 kmph and ensure safety of NMT users.
- **Local Street:** A street primarily for access to residence, business or other abutting property. Its primary function shall be for local activities and access to properties and not through movement of traffic. Local streets may not have a dedicated footpath and can be designed as shared space that gives priority to NMT modes. Various traffic calming elements will be employed to ensure that vehicle speeds are below 20 kmph, safe for intermingling of pedestrians, cyclists, and motor vehicles.

- **NMT Streets and Greenways:** All motorised traffic will be prohibited, using barriers and enforcement of regulations to prevent their entry and encroachment of NMT space. Such streets will be designed in compliance with universal accessibility guidelines, with bicycle parking, and access for emergency response vehicles.

2.2 Functions

The functions of different categories of urban roads are discussed in Manual for Planning and Development of Urban Roads and Streets.

2.3 General Consideration

The principal factors to be considered in designing urban roads are the travel desire lines of people by various modes of travel, the safety and access needs of adjacent land, network pattern, existing and proposed land-use. Besides classification of the road, other factors like type of traffic, effect on environment, drainage and maintenance must also be given prime consideration. For example, mixed conditions of traffic require careful consideration of grades, climbing lanes, curvature etc. Consideration should also be given to see that the road and its structures blend with the environment and produce a pleasing appearance. Noise and fume pollution is a problem in urban areas and the cross-section should provide for remedial measures such as noise barriers, and adequate distance should be kept between busy routes and adjacent populated areas.

3 DESIGN CONTROLS

The design of road is that of a three dimensional structure which should be safe, efficient, functional and economical for pedestrians and non motorised vehicles and motorized vehicular traffic. The design controls are human factors, road space allocation, speeds, design vehicles and sight distances.

3.1 Definitions of Various Speeds

Speed is an important element in geometric design. The factors influencing speeds are driver characteristics, vehicular characteristics, road characteristics, traffic composition and weather. Design speed and posted speed are key instruments, which can be used to regulate the speed of motor vehicles through road design and enforcement.

- **Design Speed:** The speed selected as a safe basis to establish appropriate geometric design elements for particular sections of road. It should be a logical one with respect to topography, anticipated operating speed, the adjacent land use and functional classification of road.
- **Posted Speed:** It is a speed limitation set for reason of safe traffic operations on a particular stretch of road keeping in view the prevailing geometric condition and land use characteristics. Selection of posted speed is an operational decision.

The other speed metrics such as Operating Speed is defined as 85th percentile speed of cars at low volumes (8 sec headway). Operating speed and design speed should be correlated to each other. If there is much difference, it might lead to violations on the ground. Further, running

speed, which measures the average speed maintained over a given route, is not an effective metric for designing urban roads as it does not help understand the specific geometry of a given road stretch and its impact on speeds.

3.2 Design Speed

Speed is used as a design criterion to influence the geometric design of an urban road. Embracing a proactive design approach on new and existing urban roads and streets with the goal of reducing speeds "may be the single most consequential intervention in reducing pedestrian injury and fatality." Higher design speeds cften mandate larger curve radii, wider travel lane widths, on-street parking restrictions, guardrails, and clear zones. Lower design speeds reduce observed speeding behaviour, providing a safer road for people to walk, park, and drive. Design speed is a critical input for many geometric elements such as horizontal alignment, vertical alignment and cross section elements.

Keeping in view type of function expected of each class of the urban road system, the design speeds proposed are given in **Table 3.1**. The design speed should preferably be uniform along the given road/street. The design speeds for both mountainous and steep terrain may be the same. In view of administrative difficulties in classifying arterial and sub-arterial as distinct function, same speeds are proposed for both these classes.

Table 3.1 Proposed Design Speeds (km/h)

S.No.	Class of Urban Road	Type of Terrain		
		Plain	Rolling	Mountainous and Steep
1	Urban Expressway	80	70	60
2	Arterial Road	60	50	40
3	Sub Arterial Road	60	50	40
4	Collector Street	40	40	30
5	Local Street	30	30	20

3.3 Posted Speed

While design speeds should be uniform over a road stretch, a lower value compared to that designated in **Table 3.1** may be adopted for posted speed depending on the presence of physical controls, roadside development and related factors. For example, a posted speed of 20 kmph may be adopted in the vicinity of schools, colleges, universities, hospitals, 500 m around mass transit stations, dense urban cores and central business districts. The sudden change in posted speeds along a stretch of road should be avoided. Changes should be made in stages in steps of 10 kmph at a time.

4 SPACE STANDARDS

The space standards recommended for the various categories of urban roads are given in **Table 4.1**. The term" space standard" is often referred to as "right-of-way" (IRC Manual on Planning and Development of Urban Roads and Streets).

Table 4.1 Recommended Land Widths for Roads in Urban Areas

S.No.	Type of Urban Road/Street	Land Width (m) and Type of Terrain		
		Plain	Rolling	Hilly
1	Urban Expressway	45-75	35-60	30-50
2	Arterial Road	45-60	35-50	25-40
3	Sub Arterial Road	30-45	25-35	20-30
4	Collector Street	15-30	12-25	12-20
5	Local Street	10-15	10-15	10-15

5 CROSS-SECTIONAL ELEMENTS

The width and layout of urban road cross-section depend on many factors, the chief amongst them being the classification of road, design speed, and the volume of traffic expected. Other considerations are requirements of parking lanes, bus-bays, loading-unloading bays, occurrence of access points, volume of pedestrians and cyclists, width of drains, location of sewer lines, electricity cables and other public utility services.

5.1 Footpath

Footpaths are defined as any area primarily used by 'all' pedestrians. They can be adjacent to roadways or away from the road. A footpath should consist of a dead or frontage zone, pedestrian zone and a multi-functional zone (IRC:103). See **Fig. 5.1**.

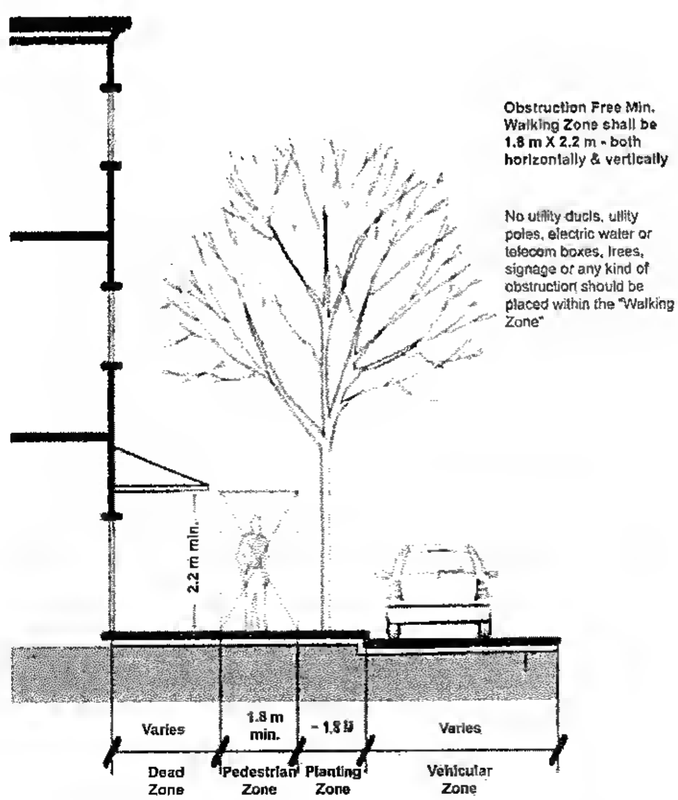


Fig. 5.1 Different Zones of a Footpath (Source: IRC:103)

- **Frontage Zone or Dead Zone:** A dead space in front of active commercial frontage is required for passive slow speed window shoppers clear from the regular pedestrian movement space to avoid conflict and increase the walking space capacity.
- **Pedestrian Zone:** An uninterrupted walking zone of minimum 1.8 m (width) and 2.2 m (height) shall be provided. No tree branches, trees, utility poles, electric/ water/telecom boxes or sign age should be placed within the clear height and width of the pedestrian zone. However, subject to this minimum, the width of the zone shall be based on the design flows and levels of service outlined in **Tables 5.1 and 5.2**.
- **Multi-Functional Zone:** A multi-functional zone (also known as a Planting Zone or Street Furniture Zone) of minimum 1-2 m width (depending on the hierarchy of urban road) shall be provided between the pedestrian zone and carriageway to provide amenities for road users and also to help smooth and orderly movement of all kinds of traffic. It shall accommodate tree planting and planting for storm water management, auto-rickshaw stands, cycle-rickshaw stands, hawker zones, paid car parking, bus stops, traffic police booths, MTNL boxes, fire hydrants, junction boxes, etc, street lights/pedestrian lights. Verges are not required for urban roads, as their role is served by the multi-functional zone of a footpath.

Table 5.1 Minimum Width of Pedestrian Zone as per Adjacent Land Use

S. No.	Zone Type	Minimum Width (m)
1	Residential Zone	1.8
2	Commercial Zone	2.5
3	High Intensity Commercial Zone	4.0

Table 5.2 Capacity of Pedestrian Zone (in Footpath)

S. No.	Width of Pedestrian Zone (m)	Design Flow in Number of Persons Per hour			
		In Both Directions		All in One Direction	
		LOS B	LOS C	LOS B	LOS C
1	1.8	1350	1890	2025	2835
2	2.0	1800	2520	2700	3780
3	2.5	2250	3150	3375	4725
4	3.0	2700	3780	4050	5670
5	3.5	3150	4410	4725	6615
6	4.0	3600	5040	5400	7560

- The height of a footpath shall not exceed 150 mm above the carriageway.
- Footpath surface shall be evenly paved and smooth for all users, including those on wheelchairs.

- Footpaths and other elements of the pedestrian environment should be accessible to all users, in compliance with Harmonised Guidelines and Space Standards for Barrier-Free Built Environment for Persons with Disability and Elderly Persons (2016) of the Ministry of Housing and Urban Affairs.
- Footpath shall be continuous even at property entrances for uninterrupted pedestrian movement. The height of the footpath shall remain the same. To provide access to private properties, vehicle ramps should be provided in the furniture zone with a gradient of 1:6 (**Fig. 5.2**).
- Footpaths should have a well maintained surface with cross fall neither so flat as to be difficult to drain nor so steep as to be dangerous to walk. The cross fall of 2.5 to 3 per cent should meet this requirement.

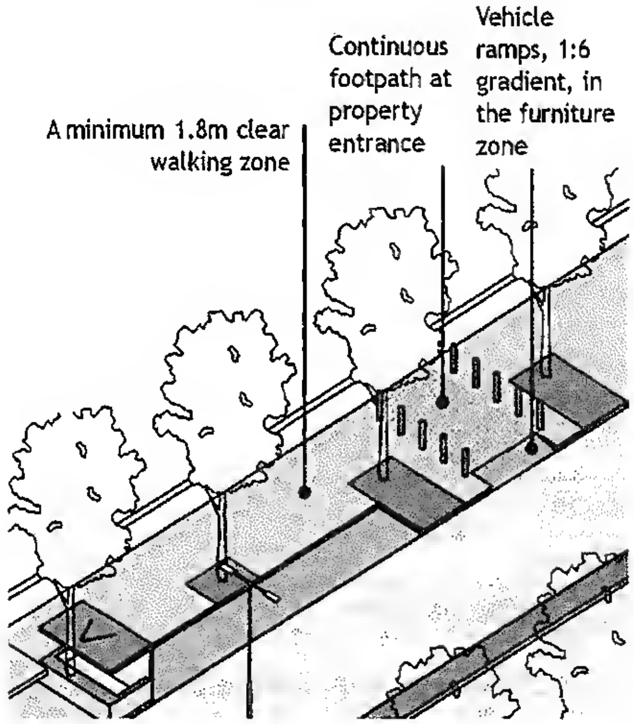


Fig. 5.2 Footpaths at Property Entrances

5.1.1 *Capacity and clear pedestrian zone*

The width of the pedestrian zone is fundamental to the effective functioning of the pedestrian system. A minimum width of 1.8 m for an uninterrupted pedestrian zone is recommended for residential areas, which shall increase based on adjoining land uses. Subject to the minimum widths in **Table 5.1**, the capacity of the pedestrian zone shall be determined by the design flows recommended in **Table 5.2**. Footpaths should normally be designed for a Level of Service B, thereby providing wide pedestrian facilities for pleasant and comfortable walking. Under resource constraint, Level of Service C can be adopted.

5.1.2 *Medians and mid-block pedestrian crossings*

- The divider between a two way traffic lane is called median.
- The maximum height of median kerb is 150 mm. Medians shall be designed as surmountable pedestrian refuge to enhance pedestrian safety. Roads with 4 or

more traffic lanes shall have medians with pedestrian refuge of minimum 3 m waiting area (IRC:103), with bollards located in the refuge space to enhance pedestrian safety.

- The minimum width of a median should be 1.2 m. As far as possible, the median should be of uniform width in a particular section. However, where changes are unavoidable, a transition of 1 in 15 to 1 in 20 must be provided.
- Instead of fences, medians should be landscaped and used for storm-water filtration and management wherever possible.
- Pedestrian crossings will be constructed as raised crosswalks, or painted zebra crossings. Zebra crossing will comply with IRC:103.
- Mid-block pedestrian crossings will be located based on the typology of urban road and range from 50-200 m.
- At unsignalized crossings, raised crosswalks shall be constructed. Raised crosswalks shall have a minimum width of 3 m, elevated to the level of the adjacent footpath, with ramps for motor vehicles with a slope of 1:8 (IRC:103) (**Fig. 5.3**).

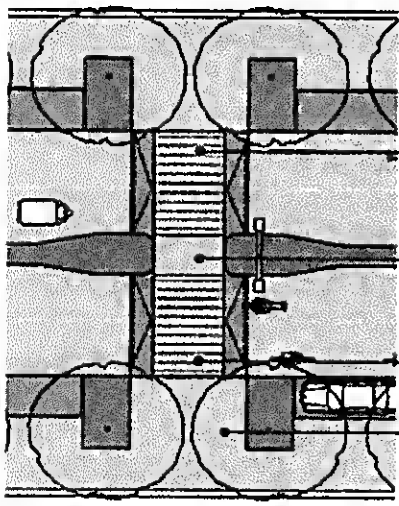


Fig. 5.3 Raised Pedestrian Crossing Reduces Vehicle Speed, thereby Increasing Pedestrian Safety

5.1.3 *Pedestrian crossings: intersection*

- At unsignalized intersections, raised crossings shall be provided to ensure pedestrians can cross safely. They shall be elevated to the level of the adjacent footpath, with ramps for motor vehicles with a slope of 1:8 (**Fig. 5.4**).
- Smaller turning radii increase pedestrian safety by reducing vehicle speeds. Turning radii at intersections of arterial and major collector roads shall not exceed 9 m. The turning radii for minor collector roads and local streets shall not exceed 4 m.
- Pedestrian crossings will be located in alignment with pedestrian desire line-pedestrian travel path.

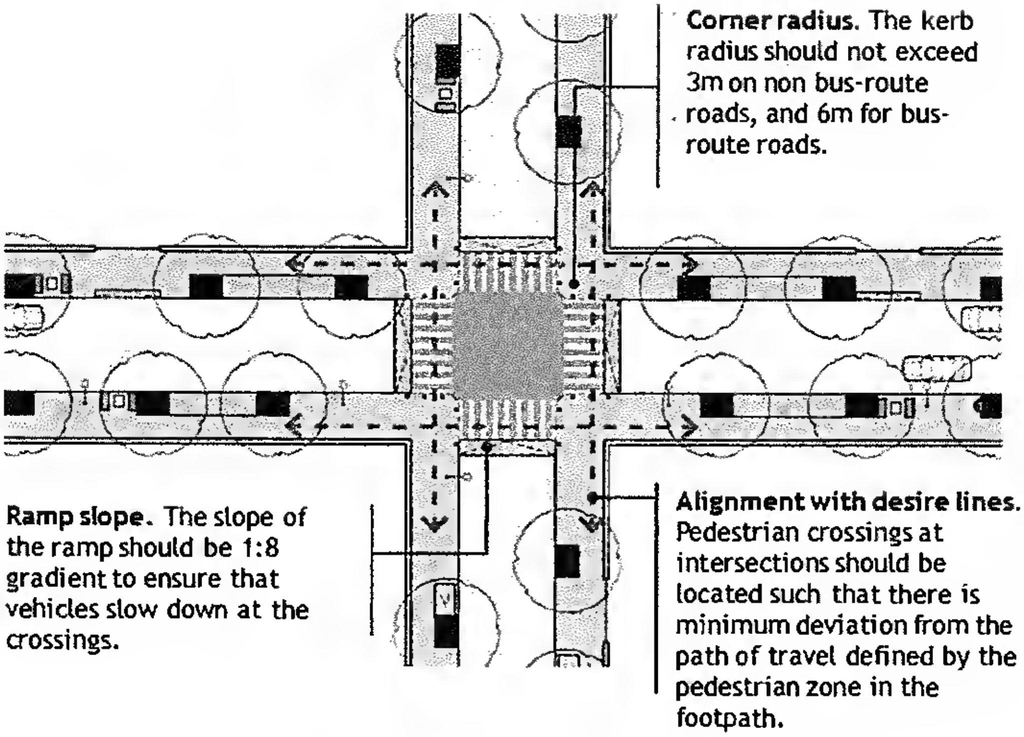


Fig. 5.4 Raised Pedestrian Crossing at Intersection

- Slip roads are undesirable from a pedestrian and cyclist safety standpoint and should be discouraged. Slip roads are meant for the "signal free" movement of traffic, and to spare the left turning motorized traffic from having to wait at traffic lights for taking a turn, but this design this design feature makes it difficult for pedestrians, cyclists, aged and person with disabilities to cross the street safely.

5.1.4 *Cross falls*

Cross falls should only be provided where it is absolutely necessary for drainage purposes and should be 1:50 maximum. If the change in cross fall is so severe that one wheel of a wheelchair or one foot of a walker leaves the ground, it may cause the user of the wheelchair or walker to fall. Steeper gradients tend to misdirect buggies and wheelchairs. Where falls are not adequate, silt will accumulate after rain and cause the surface to become slippery. Puddles also cause the footpath to become slippery, lead to glare in bright sunshine after other parts of the footpath have become dry and become a hazard in frosty weather. Any break in the surface, e.g. drainage channels or the gaps between boards on a walkway, should not be more than 12 mm and should cross perpendicular to the direction of movement. This will prevent walking sticks and wheels getting caught in the gaps.

5.1.5 *Service covers*

Service covers to manhole and inspection chambers should not be positioned on footpaths, particularly at dished crossings. They can be dangerous when opened for inspection, forming a tripping hazard and reducing the clear width. Covers and gratings should be non-slip, flush/ levelled with the footpath surface, and be such that openings are not more than 10 mm wide. Gratings and slot type drainage should be sited away from pedestrian flows and perpendicular to the main line of pedestrian flows so as not to trap small wheels.

5.1.6 *Pedestrian guardrails*

Pedestrian guard-rails are an important design element to prevent indiscriminate crossing and spilling over of pedestrian on to the carriageway. Their judicious use can help to ensure that pedestrians cross the streets at predetermined and safe locations. As the guard-rails would confine the movement of pedestrians to the footpath, it is obligatory that sufficient width of footpath be made available (IRC:103).

5.1.7 *Bollards*

Bollards are often used to stop vehicles from mounting the footpath and to keep pedestrian away from traffic. Unless positioned carefully, they can form a barrier to wheelchair users and are a particular hazard for persons with visual impairments. Where they are essential, such as to ensure clear escape routes, bollards should be identifiable by using contrasting colours by providing reflective tapes and be minimum 1000 mm high. To stop use by bicycles/bikes bollards at suitable locations should be provided with clear gap/space between two bollards should be 1200 mm.

5.1.8 *Zebra crossings*

The width of the zebra crossing must be adequate and should generally lie within a range of 2-4 m. For divided carriageways, the crossing should, as far as possible, proceed uninterrupted through the median strip. In the event of the median strip being used as pedestrian refuge, adequate width of median must be provided. In case of raised medians, such portion could be suitably depressed with kerb height not exceeding 150 mm.

5.1.9 *Grade-separated pedestrian and cycling facilities*

Foot-over bridges and subways increase the walking distance for a pedestrian/commuter, which is inconvenient and therefore discouraged to the extent possible. The design guidelines are given in **Annexure I.**

5.1.10 *Landscaping*

- All footpaths shall have a continuous tree line to provide shade and improve the aesthetics of the streets cape. (**Fig. 5.5**).
- Placement of landscaping shall be coordinated with other street amenities (especially advertising panels and utility boxes) to maintain a clear path of travel for pedestrians and cyclists so as not to obstruct their through movement.
- Height of trees shall be maintained so that it does not hinder the visibility of all road users. Canopy of trees shall have a minimum clearance of 3 m from the surface of the footpath to ensure better visibility for pedestrians.
- Native trees shall be planted to minimize irrigation and maintenance requirements, and for a prolonged tree life.
- All trees will be protected with tree pits that allow maximum soil exposure enabling water and air to get to the roots.
- Tree pits, with a minimum dimension of 1 m x 1 m, shall be provided to accommodate the growth of root structures as tree matures.

Fig. 5.5 Placement of Trees in the Multi-Functional Zone

5.2 Non-Motorized Vehicle Tracks

Non-Motorized Vehicles (NMV) include cycles, tri-cycles, cycle rickshaws, pushcarts, and any other form of mobility that is powered by humans. These users are also called 'captive cyclists' (Non Motorised Transport Planning and Design Guideline, 2014). NMV plays an important and unique role in efficient transport systems. It is the most affordable mode of transport for groups of all ages and income groups covering diverse accessibility needs. Urban local bodies should create city-wide NMV network plans based on need assessment, to ensure that the roads and streets are safe for cycling.

The guidelines are provided below:

- Cycle tracks will have at least 2 m of clear space per direction for one-way movement and 3 m for two-way movement, and have a smooth surface asphalt or concrete. Paver blocks will be avoided.
- Painting cycle tracks, without segregation, shall be discouraged as they are likely to be encroached by parked vehicles. They shall be elevated 100-150 mm above the carriageway.
- A buffer of 0.5 m between the cycle track and parking areas or the carriageway shall be constructed.
- In compliance with IRC:11-2015, cycle tracks shall be provided on streets that have more than 100 motor vehicles and 400 cyclists during peak hour.
- Median cycle tracks reduce conflicts with parking and property access. Frequent access points with ramps are essential. Turning movement conflicts at intersections can be mitigated through bicycle boxes and appropriate signal phasing.
- Comprehensive standards for infrastructure for NMV are given in **Table 5.3** adapted for use by persons with reduced mobility and persons with disabilities, particularly tri-cycle users (tri-cycle width range from 800 mm - 1000 mm).

Table 5.3 Infrastructure for NMV

Elements	Arterial Roads	Major Collector Streets	Minor Collector Streets	Local Streets
Non-motorized vehicle	Segregated cycle track	Segregated cycle track	Mixed traffic; traffic calmed streets with design speeds <30 kmph	Mixed traffic
Location	Can be a median cycle track, side tracks as per Annexure 2: Street Design Templates			
Gradient	1:12-1:20 (minimum) Level to be negotiated 1 m: 1:12-1:20 2 m: 1:30-1:50 5 m: 1:30-1:50 Rail over bridge: 1:40-1:60			
Height	• Should be 50 mm lower than footpath height • Should not be the lowest part of the RoW • Ensure water does not log in the cycle track		Not applicable	Not applicable
Minimum width	2 m for a one-way cycle track; 3 m for a two-way track		Not applicable	Not applicable
Surface	Smooth surface-concrete (broom finish)			
Lighting	20 lux at 12-16 m spacing for a light pole 6 m			
Marking	Cycle symbol on surface and lanes marked at intersections. The lanes should be painted in contrast color to surface			

The capacity of cycle tracks are given in **Table 5.4**.

Table 5.4 Capacity of Cycle Tracks

Width of Cycle Track	Capacity in Number of Cycles/Hour	
	One Way Traffic	Two Way Traffic
2 lanes (3 m)	250 - 600	50 - 250
3 lanes (4.5 m)	Over 600	250 - 600
4 lanes (6 m)	---------	Over 600

5.3 Road Width and Design Traffic Volumes

The road width should be designed to accommodate the design traffic volume. Past traffic counts and consideration of future development of urban areas must be kept in view while selecting the cross-section of road. Estimation of future traffic volumes may be based on a simple projection of current volumes extrapolated from past trends, or on the basis of results of transportation study which allows for change in land-use and accounts for socio-economic factors. The road should be designed to accommodate the traffic volumes computed for the end of design life. A design period of 15-20 years should be adopted for expressway and arterials and 10 years for local and collector streets. For broad assessment, the peak hour flows may be taken as 8-10 per cent of the average daily traffic.

Urban roads in India are characterised by mixed traffic conditions, resulting in complex interaction between various kinds of vehicles. To cater to this it is prudent to express the capacity of urban roads in terms of a common unit. The unit generally employed is the 'Passenger Car Unit, (PCU) and each vehicle type is converted into equivalent PCUs based on their relative size and speed. The equivalent PCUs of different vehicle categories do not remain constant under all circumstances. Rather, these are the function of physical dimensions and operational speeds of a vehicle type. The PCU is a measure of relative interaction caused by a vehicle to the traffic stream compared to passenger car under a specified set of roadway, traffic and other conditions. This interaction will depend on traffic, roadway and environmental conditions. For a given facility, roadway and environmental conditions remain almost unchanged during field observation time and therefore, traffic characteristics like traffic composition, traffic volume, speed and size of each category of vehicle must be able to explain the variations in PCU values for a vehicle type. The physical dimension and operational speed of a vehicle class and different operational conditions are considered to account for any variation in PCU values.

The evolved base capacity values, adjustment factors and Design Service Values (DSV) encompassing varying widths of two lane two-way roads as well as varying widths of divided multilane carriageways presented in IRC:106 may be referred.

5.4 Carriageway Width

The primary purpose of a carriageway is vehicle mobility. A carriageway provides dedicated space for motorised vehicles separated from walking, cycling, and stationary activities. Carriageways are located in the middle of the right-of-way of the road. Designs should define clear boundaries through kerbs and material differences. One-way carriageways should be reviewed and provided if necessary to accommodate rapid transit (such as BRT) corridors or pedestrian zones. Where one-way streets are proposed, the ULB will provide for two-way movement for NMT modes. The lane width should be 3.5 mm carriageway widths are shown in **Table 5.5**.

Table 5.5 Recommended Carriageway Widths

S.No.	Description	Width (m)
1	Single Lane with raised kerbs	3.50
2	2- lane with raised kerbs	7.00
3	4- lane with raised kerbs	14.0
4	6- lane with raised kerbs	21.0
5	8- lane without kerbs	28.0

i) For access roads to residential areas, a lower lane width of 3 m is permissible.

ii) Minimum width of urban road without kerb shall be 5.5 m including allowances for a stalled vehicle and pedestrian movement.

5.5 Kerb and Kerb Ramp

It is desirable that roads in urban areas are provided with kerbs. Kerbs may be barrier type, semi-barrier type or mountable type. Appropriate situations for use of each type are indicated

below:

- **Barrier type**: Built-up areas adjacent to footpaths with considerable pedestrian traffic.
- **Semi-barrier type**: On the periphery of the roadway where pedestrian traffic is light and a barrier type could tend to reduce traffic capacity.
- **Mountable type**: Within the roadway at channelization schemes, medians, outer separators and raised medians on bridges.

Fig. 5.6 shows two varieties of each type of kerb with gutter and without gutter. Kerbs with gutter should always be used at drainage edges of pavements.

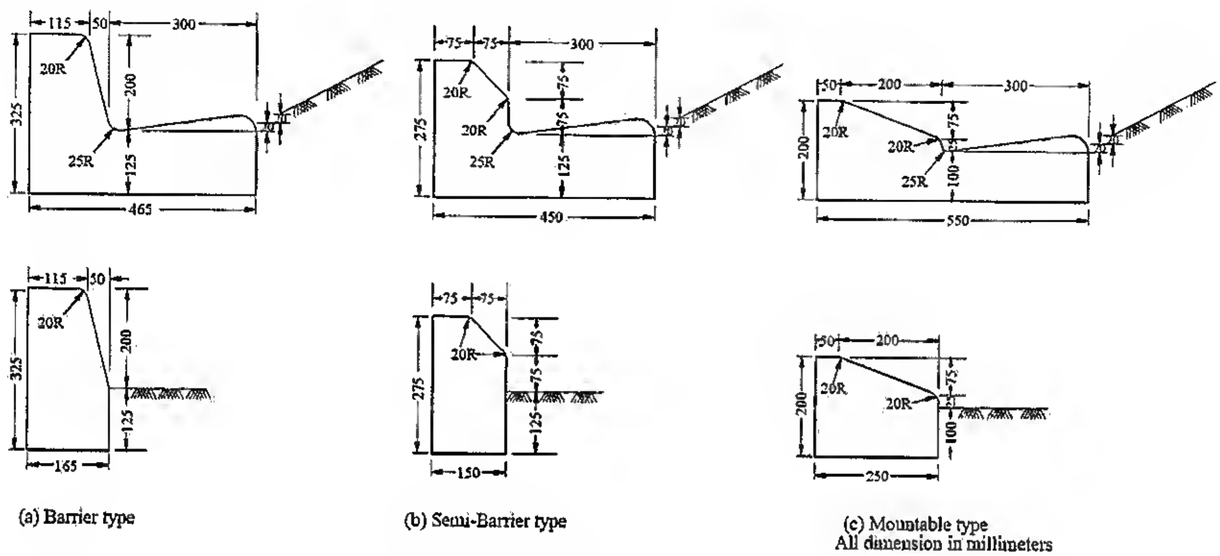


Fig. 5.6 Typical Kerb Sections

5.6 Medians

Urban roads of four lanes or more should, as a general rule, be provided with median. For four-lane roads, however, the provision of median should be judicious taking into account such considerations as safety, directional distribution of traffic, the proportion of slow-moving traffic, roadside development and quality of service, etc., Medians could be avoided where there are significant tidal flows of traffic, or where the individual carriageways are inadequate for catering to peak-hour traffic volumes, or where there are intense roadside developments without frontage roads.

Width of median is dictated by a variety of conditions. Width will depend on the available right-of-way, terrain, turn lanes, drainage and other determinants. Wide medians are preferred where space permits. Minimum width of median at intersection to accomplish various purposes should be as follows: (i) Pedestrian refuge, 1.2 m; (ii) Median lane for protection of vehicle making right turn, 4.0 m but 7.5 m is recommended; (iii) 9 to 12 metre is required to protect vehicles crossing at grade. Even greater widths are required for U-turns. Absolute minimum width of median in urban areas is 1.2 m; a desirable minimum width is 5 m.

As far as possible, the median should be of uniform width in a particular section. However, where changes are unavoidable, a transition of 1 in 15 to 1 in 20 must be provided.

5.7 Verge

Verges are required between carriageway and property line not only to accommodate lighting columns, traffic signs, underground services etc., but also to provide appropriate clearance to ensure proper vehicle placement and development of full carriageway capacity. Where road width is restricted, full width between carriageway and property line should be paved and used for pedestrian side walk/cycle track. Where possible, a minimum verge of 1 m width should be kept. They should be suitably levelled, trimmed and provided with a cross fall of 5 per cent if turfed and 3 per cent if cobbled or surface dressed. This should be increased if poles, kerb-height, or excessive cross fall discourage parking close to the kerb and also where either parked vehicles frequently overlap on to the adjacent traffic lane or the parking lane is likely to be used as a peak hour traffic lane.

5.8 Street Lighting

- Street lighting shall be provided such that the longitudinal dimension is equivalent to three times the pole height, and horizontal dimension is slightly longer than the pole.
- Pole height and spacing option are given in **Table 5.6**. The spacing between two light poles shall be approximately three times the height of the pole.
- Poles shall be no higher than 12 m to reduce undesirable illumination of private properties.
- Additional lighting shall be provided particularly at black spots, areas of potential risks to women,areas of personal crime, and areas of isolation.
- The placement of street lighting shall be coordinated with other street elements so that they do not impede proper illumination.
- A single row of light posts is generally sufficient for streets up to 12 m wide.
- On wider streets, dual lights can be mounted on a single central post.

Table 5.6 Pole Height and Spacing Metrics

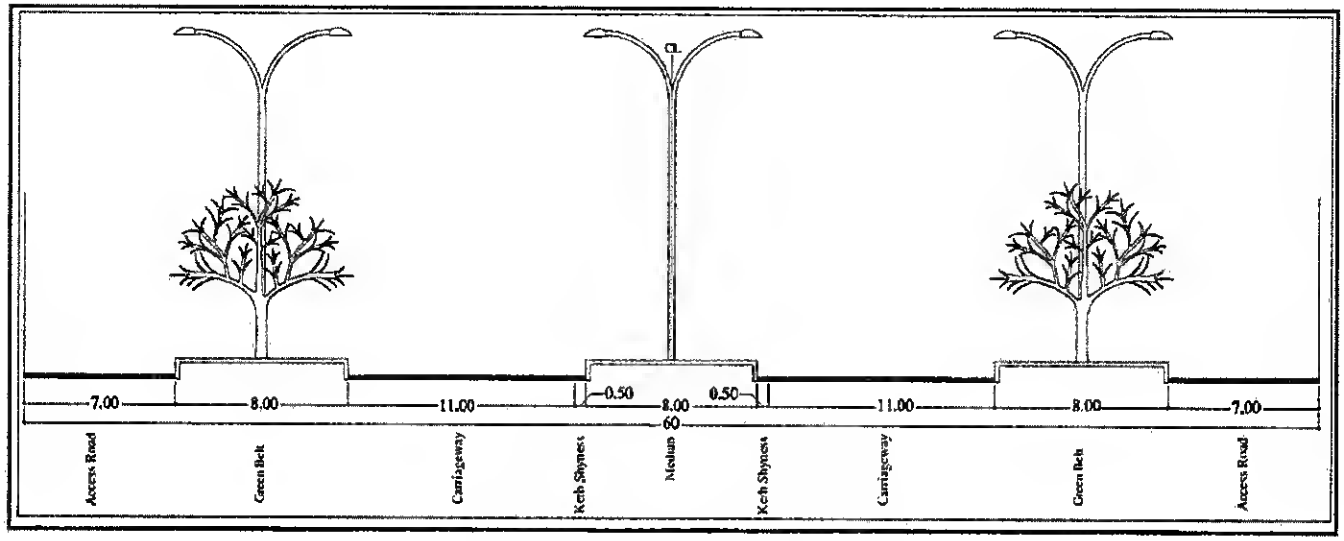
S.No.	Street Type	Pole height (m)	Spacing (m)
1	Footpath or cycle track (< 5 m width)	4.5-6.0	12-16
2	Streets with ROW of 9 m or less	8-10	25-27
3	Streets with ROW of more than 9 m	10-12	30-33

5.9 Typical Cross Sections

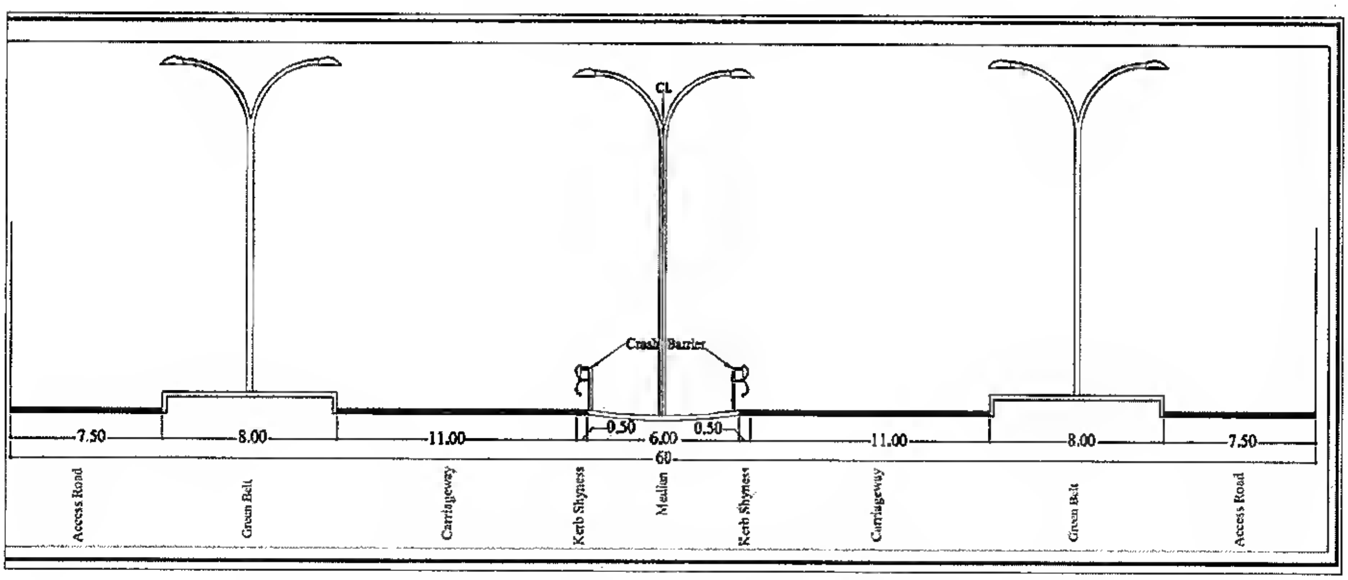
Typical cross-sections of various categories of urban roads are given in **Figs. 5.7 to 5.20** for various terrains as below:

- **Figs. 5.7, 5.8 and 5.9** shows typical cross section of urban expressways in plain, rolling and hilly terrain.

- **Figs. 5.10, 5.11 and 5.12** shows typical cross section of Arterial Roads in plain, rolling and hilly terrain.
- **Figs. 5.13, 5.14 and 5.15** shows typical cross section of Sub-Arterial roads in plain, rolling and hilly terrain.
- **Figs. 5.16, 5.17 and 5.18** shows typical cross section of Collector streets in plain, rolling and hilly terrain.
- **Figs. 5.19 and 5.20** shows typical cross section of Local streets in plain, rolling and hilly terrain.

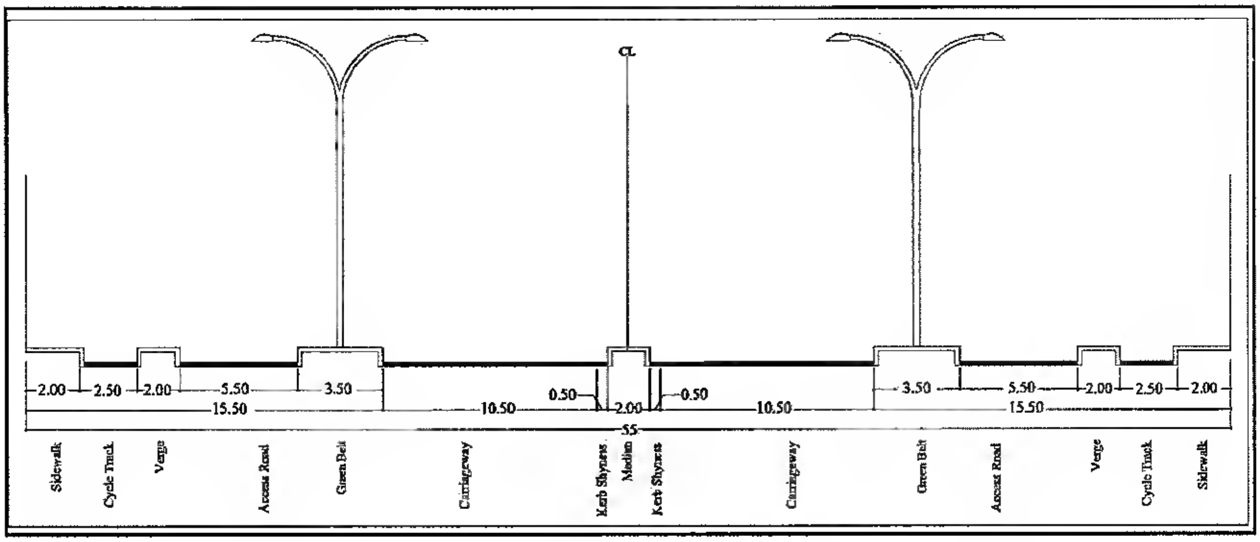


Type A1:6-Lane Raised Median



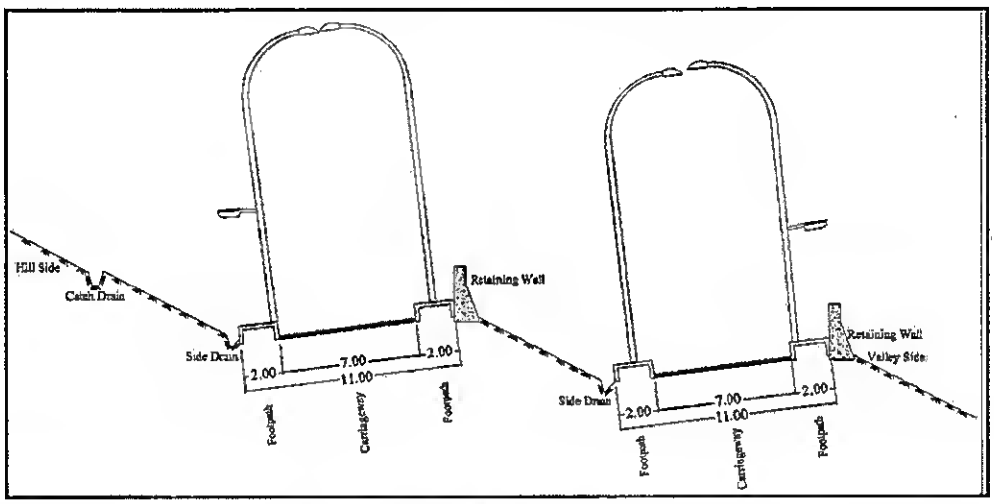
Type A2:6-Lane Depressed Median

Fig. 5.7 Typical Cross Section for Urban Expressway – Plain Terrain



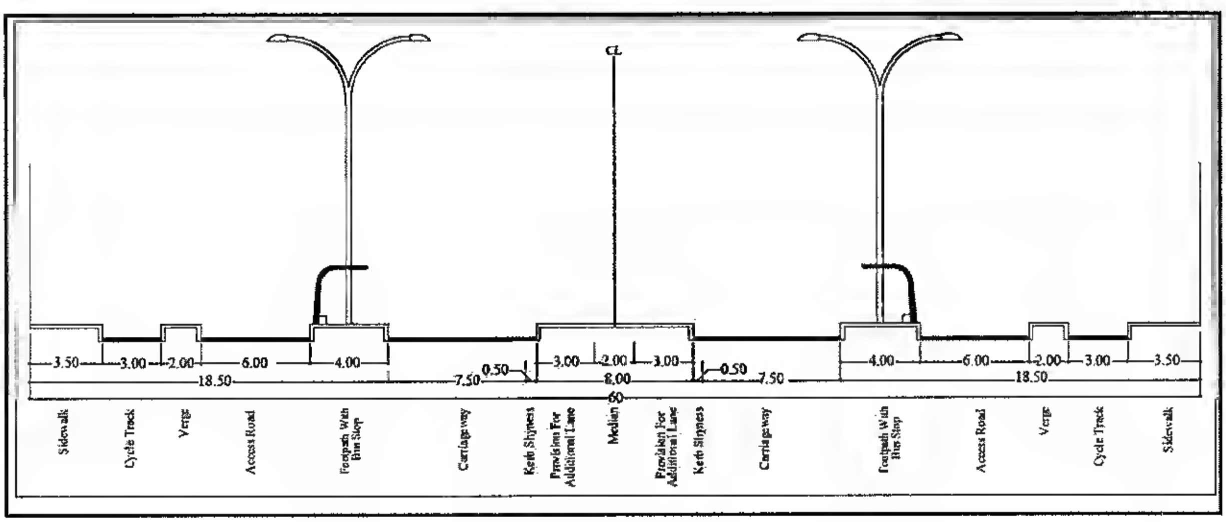
Type B1 : 6-Lane

Fig. 5.8 Typical Cross Section for Urban Expressway- Rolling Terrain

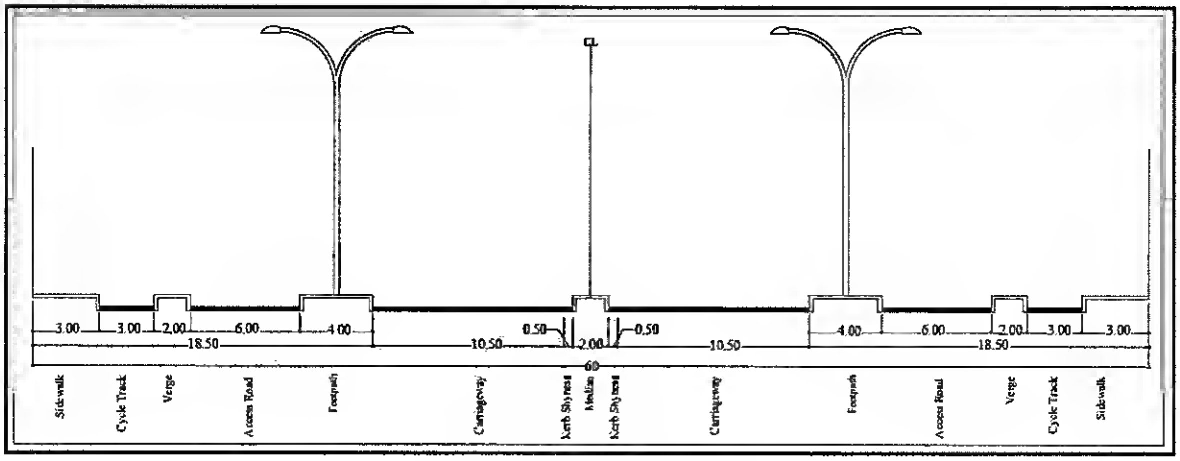


Type C1 : 4-Lane-Different Contour

Fig. 5.9 Typical Cross Section for Urban Expressway- Hilly Terrain

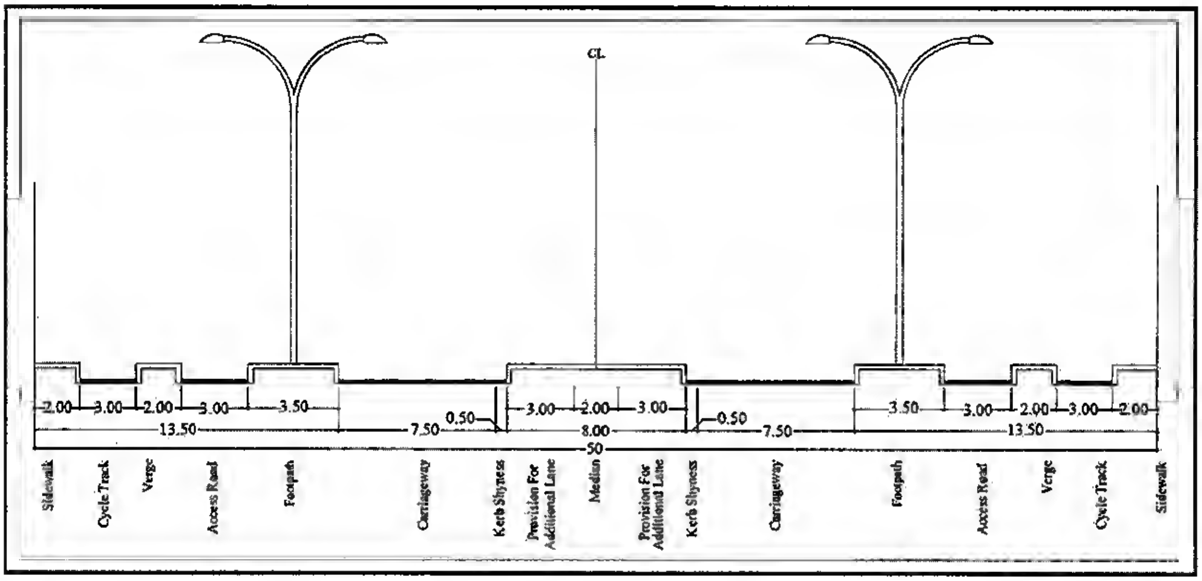


Type A1:4-Lane with Provision of 6-Lane Road

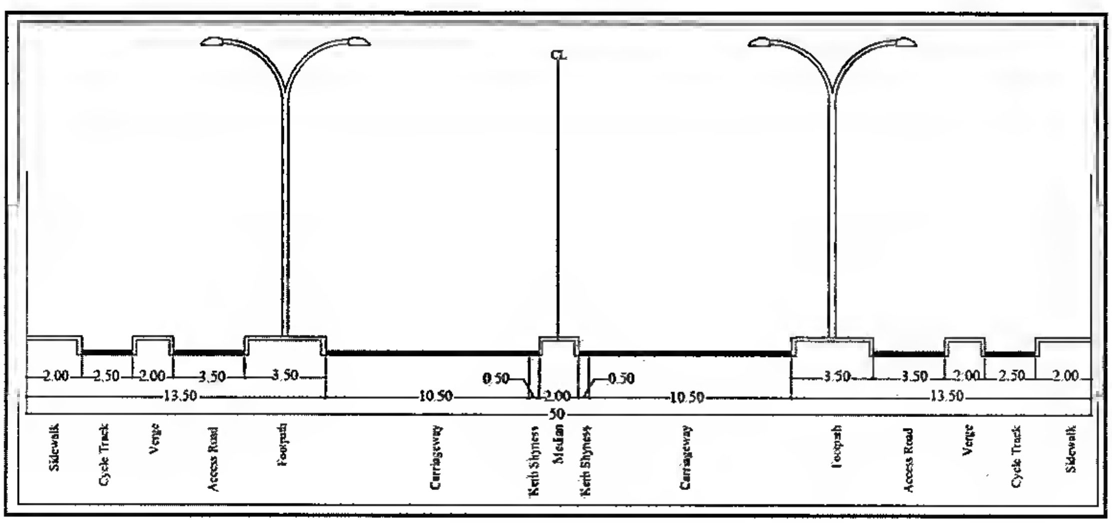


Type A2:6-Lane Divided Road

Fig. 5.10 Typical Cross Section for Arterial Roads- Plain Terrain

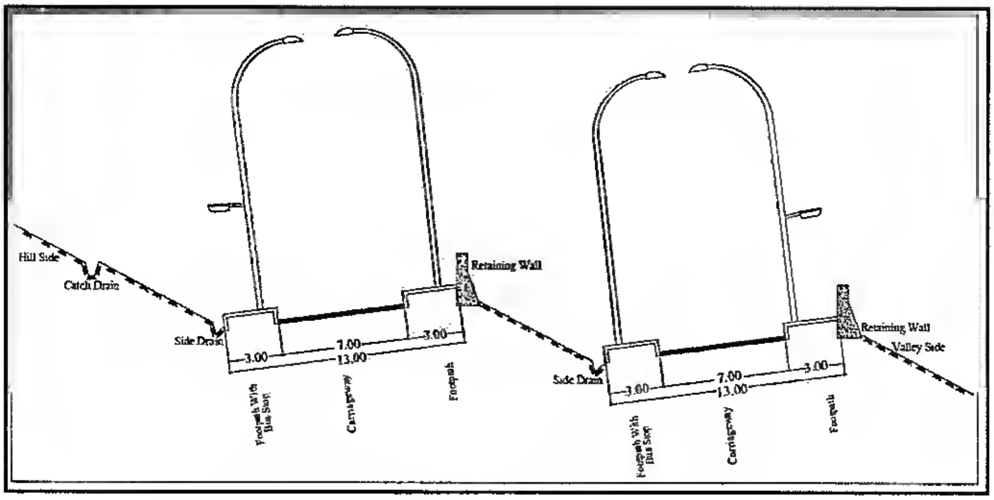


Type: B1:4-Lane Road with Provision of 6 Lane



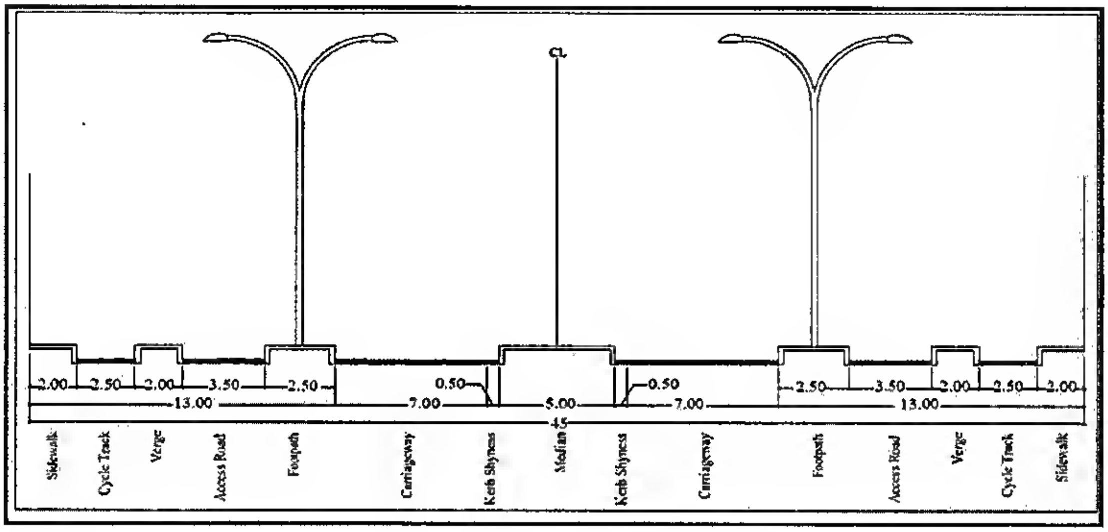
Type: B2:6-Lane Road

Fig. 5.11 Typical Cross Section for Arterial Roads - Rolling Terrain



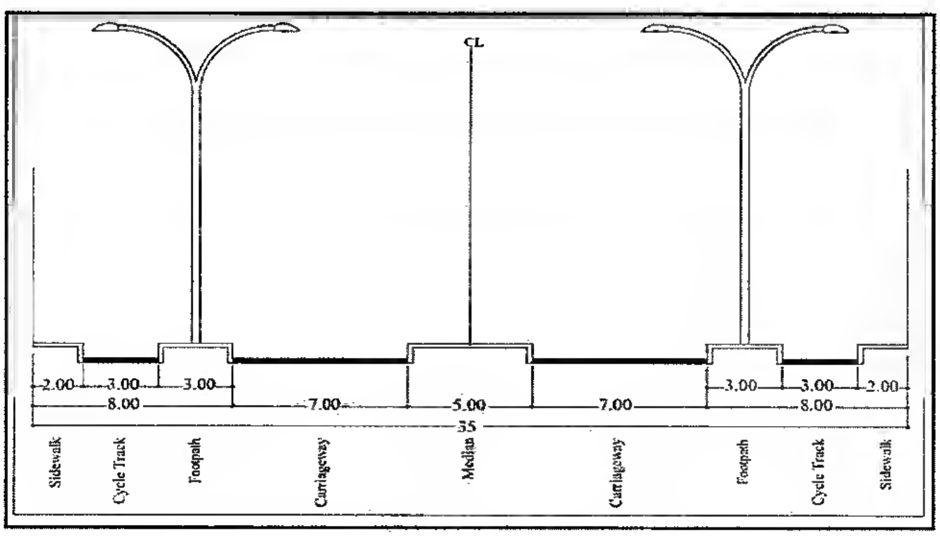
Type C : 4-Lane Road - Different Contour

Fig. 5.12 Typical Cross Section for Arterial Roads - Hilly Terrain



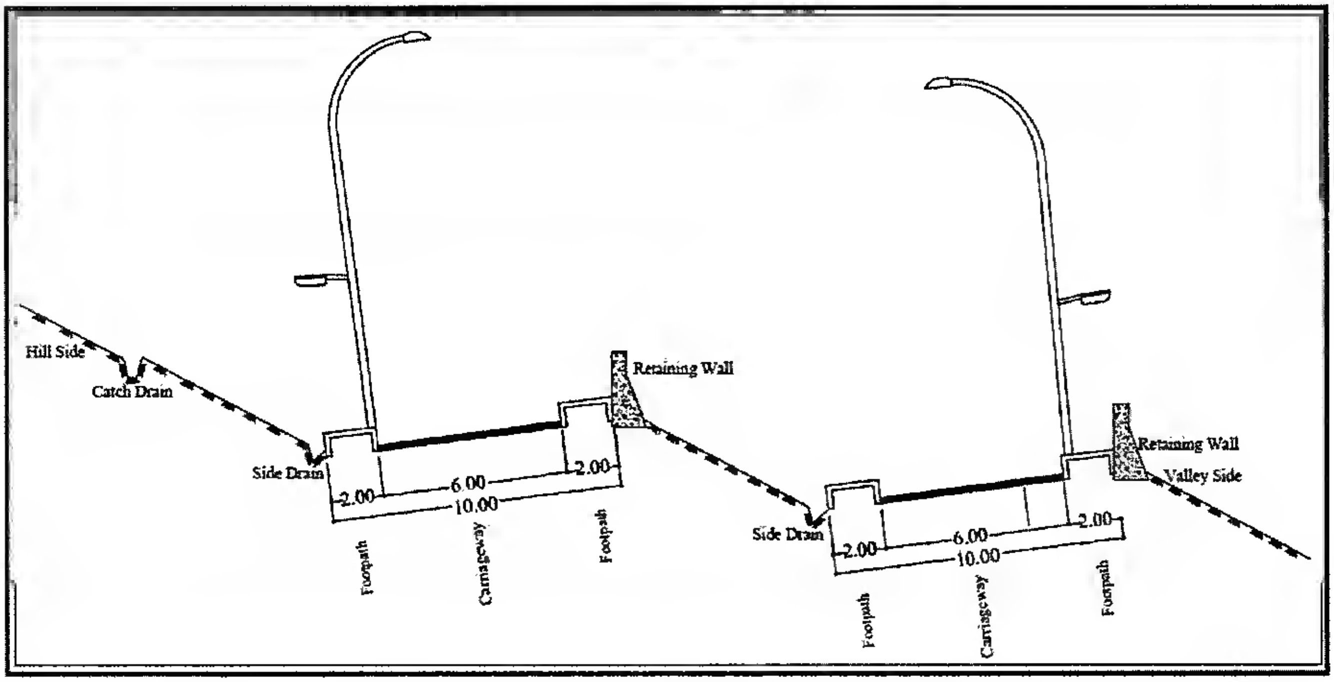
Type A : 4-Lane Divided Road

Fig. 5.13 Typical Cross Section for Sub-Arterial Road- Plain Terrain



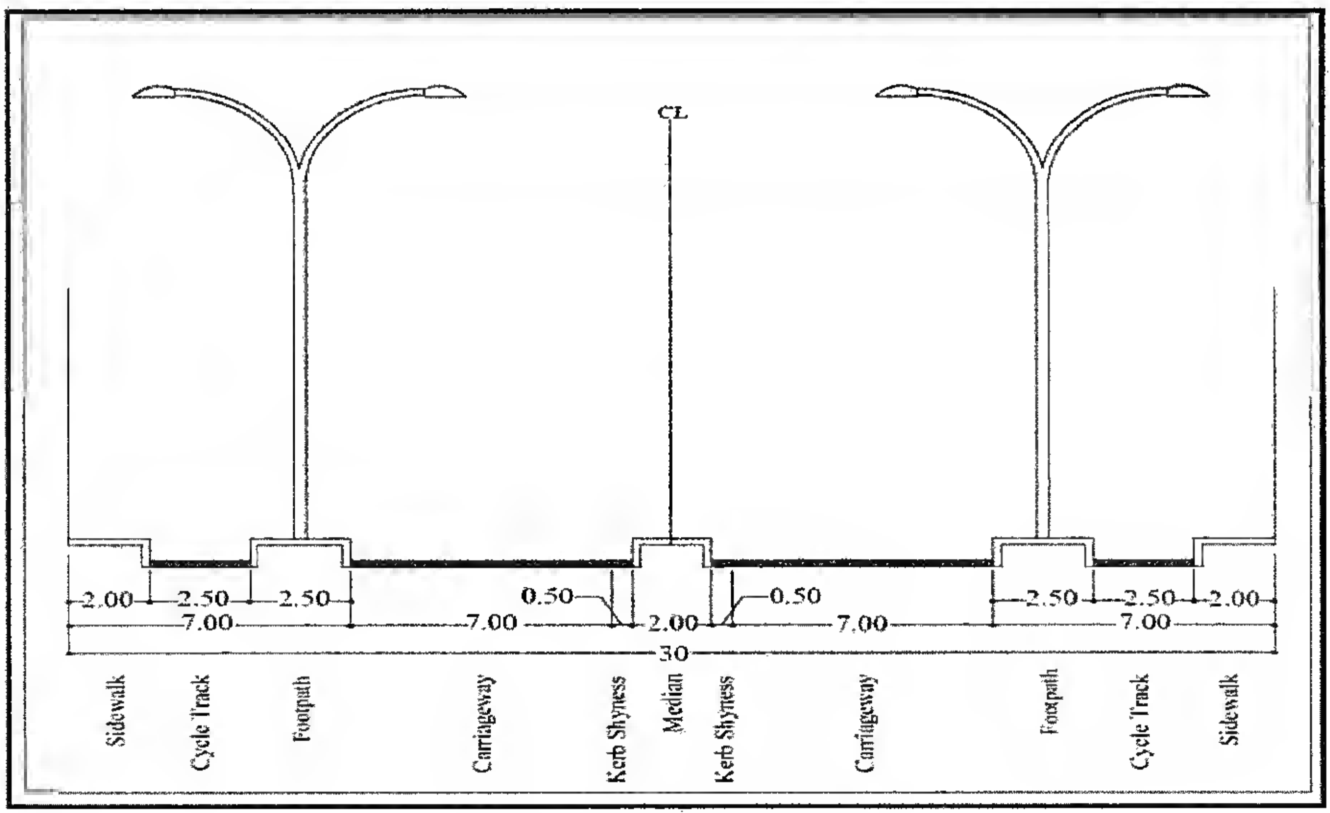
Type B : 4-Lane Divided Road

Fig. 5.14 Typical Cross Section for Sub-Arterial Road- Rolling Terrain

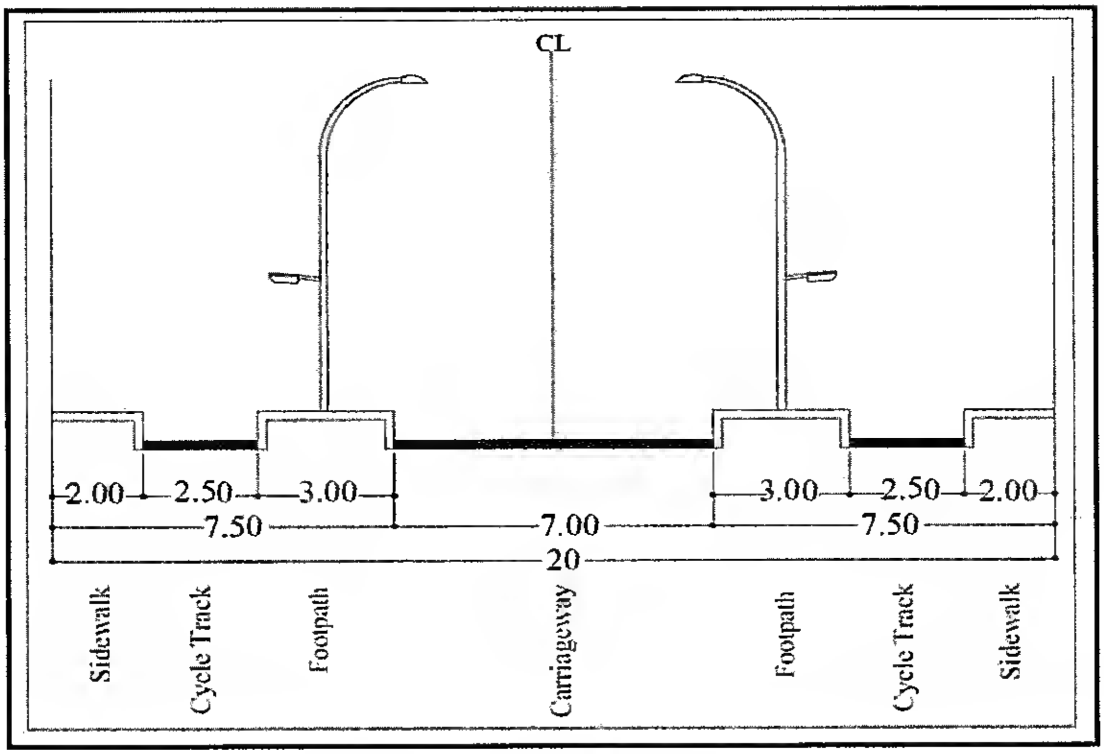


Type C : 4-Lane Divided - Different Contours

Fig. 5.15 Typical Cross Section for Sub-Arterial Road- Hilly Terrain

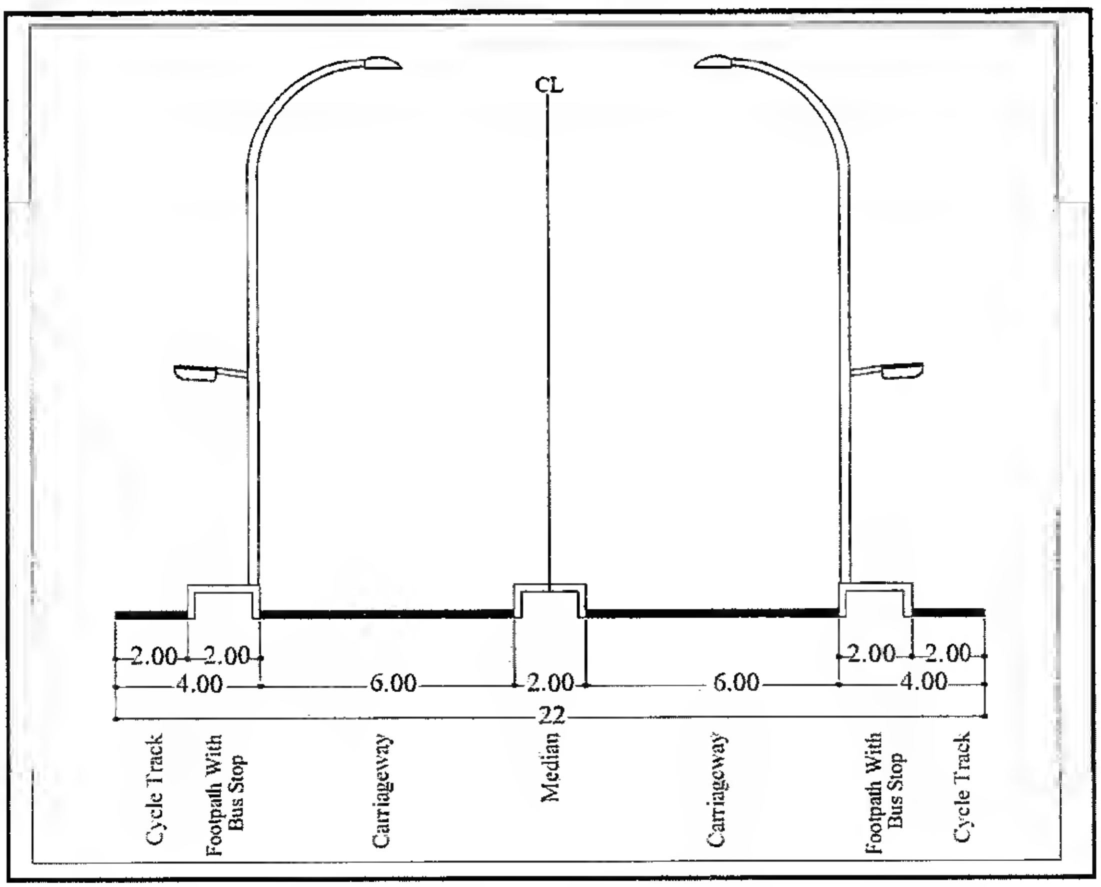


Type A1 : 4-Lane Divided Street



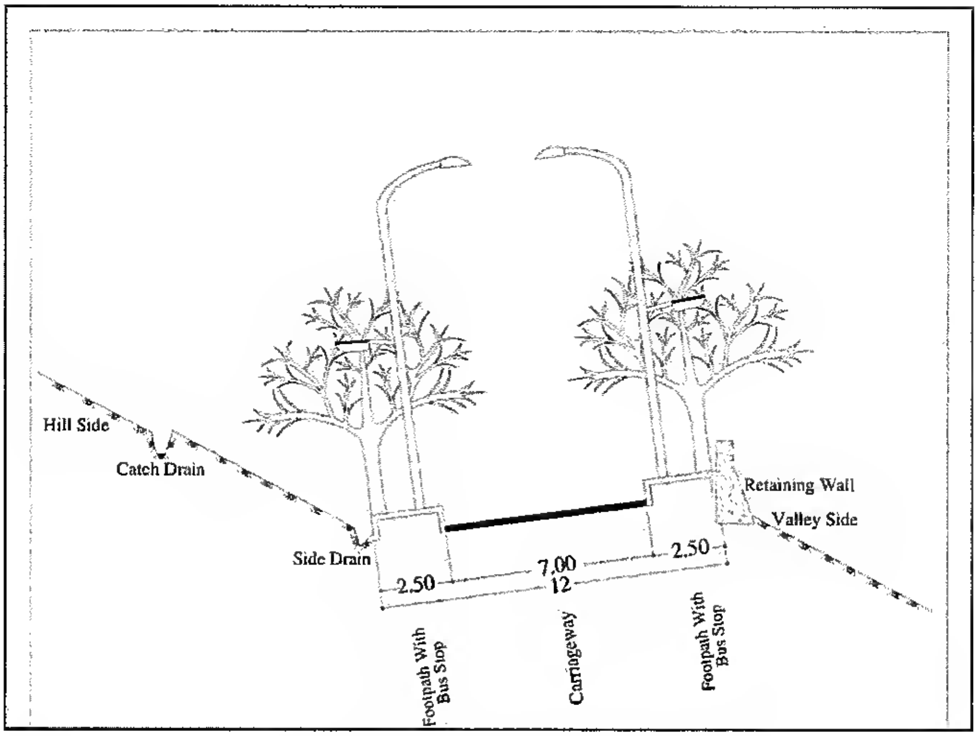
Type A2 : 2-Lane Undivided Street

Fig. 5.16 Typical Cross Section for Collector Street- Plain Terrain



Type B : 4-Lane Divided Street

Fig. 5.17 Typical Cross Section for Collector Streets - Rolling Terrain



Type C : Two Lane Undivided Road

Fig. 5.18 Typical Cross Section for Collector Streets - Hilly Terrain

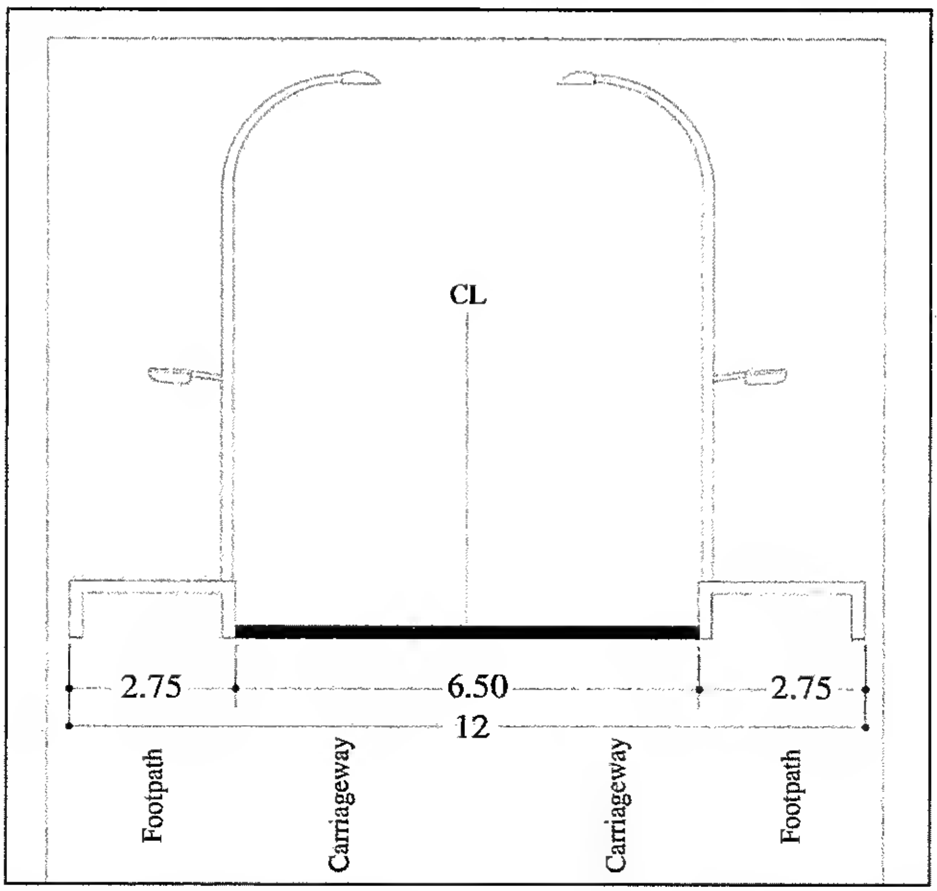


Fig. 5.19 Typical Cross Section for Local Streets- Plain/Rolling Terrain

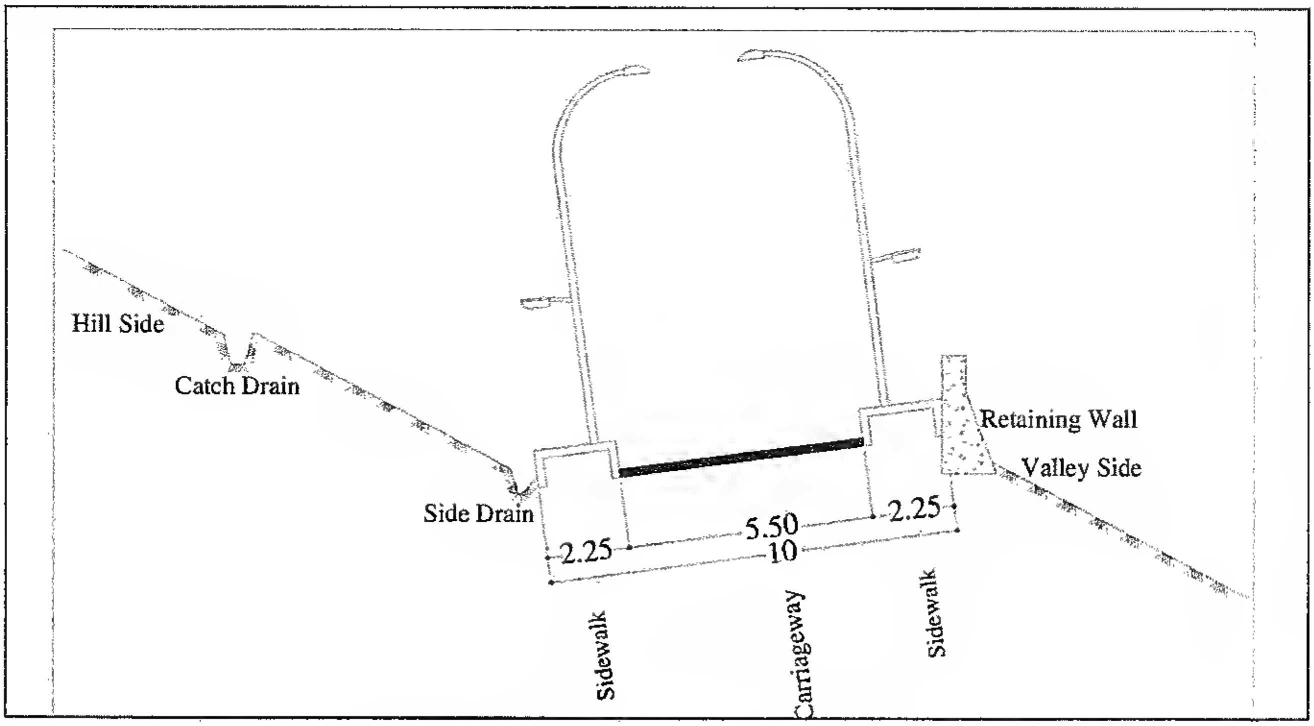


Fig. 5.20 Typical Cross Section for Local Streets - Hilly Terrain

6 CAMBER

6.1 Camber for Carriageway

Camber or cross fall should be adopted as per **Table 6.1** for straight sections Higher values of camber should be adopted in areas with high intensity of rainfall. Steeper camber should also be provided on kerbed pavement to minimise the spread of surface water flows.

Table 6.1 Camber for Carriageways

S.No.	Surface Type	Camber	
		Light Rainfall Area	Heavy Rainfall Area
1.	Thin bituminous surfacing	2 per cent (1 in 50)	2.5 per cent (1 in 40)
2.	High type bituminous surfacing or cement concrete surfacing	1.7 to 2 per cent (1 in 60 to 1 in 50)	2.0 to 2.5 per cent (1 in 50 to 1 in 40)

6.2 Camber for Shoulders

For shoulders along unkerbed pavements, the cross fall should be 0.5 percent steeper than the slope of pavement. For paved footpaths, cross fall of 3 per cent should be adopted. For verges and unpaved areas, the cross fall should be 4 per cent. Undivided carriageways should have a crown in the middle and slope towards the edges. Divided roads may have a single crowned section or separate crowned sections for each carriageway depending on requirements of drainage and access to abutting property.

7 SIGHT DISTANCE

7.1 Stopping Sight Distance

Stopping sight distance should be provided at all points on the road. Stopping sight distance is the total distance travelled by the driver from the time a danger is comprehended by him to the actual stop, i.e. the distance travelled during perception and brake reaction time plus the braking distance. For the purpose of measuring the stopping sight distance, the height of eye should be assumed as 1.2 m and height of object as 0.15 m. The design values of sight distance are given in **Table 7.1**.

Table 7.1 Safe Stopping Sight Distance for Various Speeds

S. No.	Speed (km/h)	Safe Stopping Sight Distance (m)
1	20	20
2	30	30
3	40	45
4	50	60
5	60	80
6	70	105
7	80	120

On undivided roads, intermediate sight distance which is equal to twice the stopping distance should be provided where vehicles are permitted to cross the centre line.

7.2 Headlight Sight Distance for Valley Curves

On valley curves, the design must ensure that the roadway ahead is illuminated during night travel by vehicle headlights for a sufficient length which enables the vehicle to apply brake to stop, if necessary. This is known as the headlight sight distance and is equal to the safe stopping distance. From safety considerations, valley curves should be designed to provide for this visibility. For designing valley curves, the following criteria should be followed to ensure the headlight sight distance:

- height of headlight above the road surface is 0.75 m
- the useful beam of headlight is one degree upwards from the grade of the road; and
- the height of object is nil.

8 HORIZONTAL ALIGNMENT

8.1 General

In general, horizontal curves should consist of a circular portion flanked by spiral transitions at both ends. Design speed, super elevation and coefficient of side friction affect the design

of circular curves. Length of transition curves is determined on the basis of rate of change of centrifugal acceleration and super elevation. See **Figs. 8.1 and 8.2**.

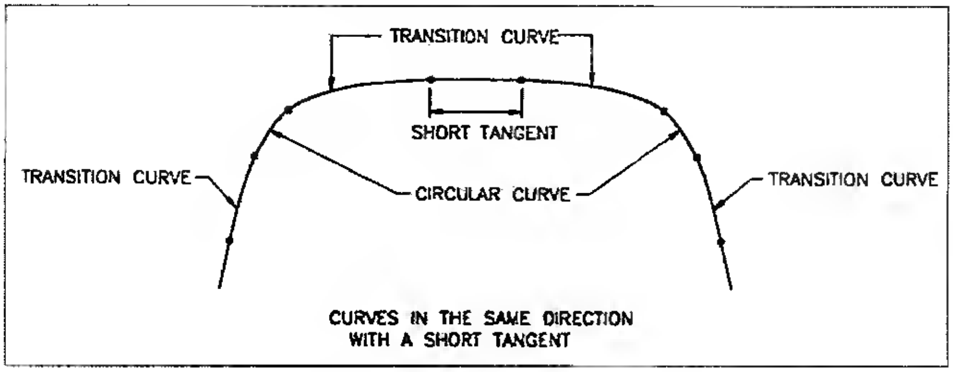


Fig. 8.1 Broken Back Curve

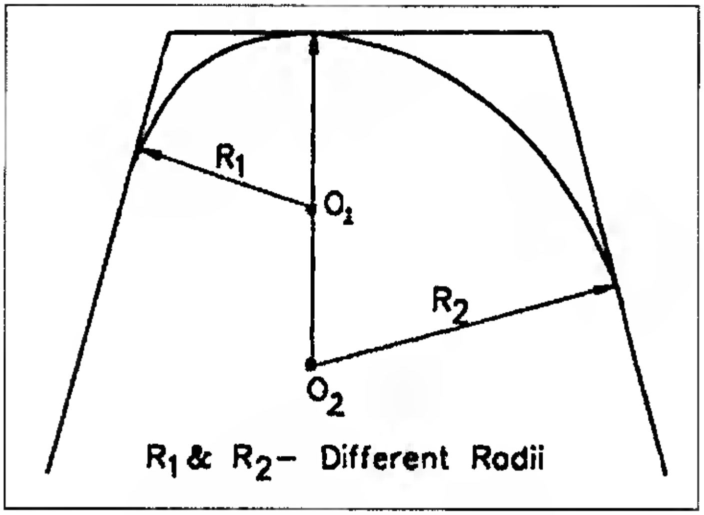


Fig. 8.2 Compound Curve

8.2 Super Elevation

8.2.1 *Design values*

Super elevation required on horizontal curves should be calculated from the following formula. This assumes the centrifugal force corresponding to three-fourth the design speed is balanced by super elevation and the remaining one fourth counteracted by side friction:

$$e = \frac{V^2}{225R}$$

where,

e = super elevation in metre per metre

V = speed in km/hr, and

R = radius in metre

Super elevation obtained from the above expression should be limited to 7 per cent. However, on urban sections with frequent intersections, it will be desirable to limit the super elevation to 4 per cent for convenience in construction and for facilitating easy and safe turning movement of vehicles.

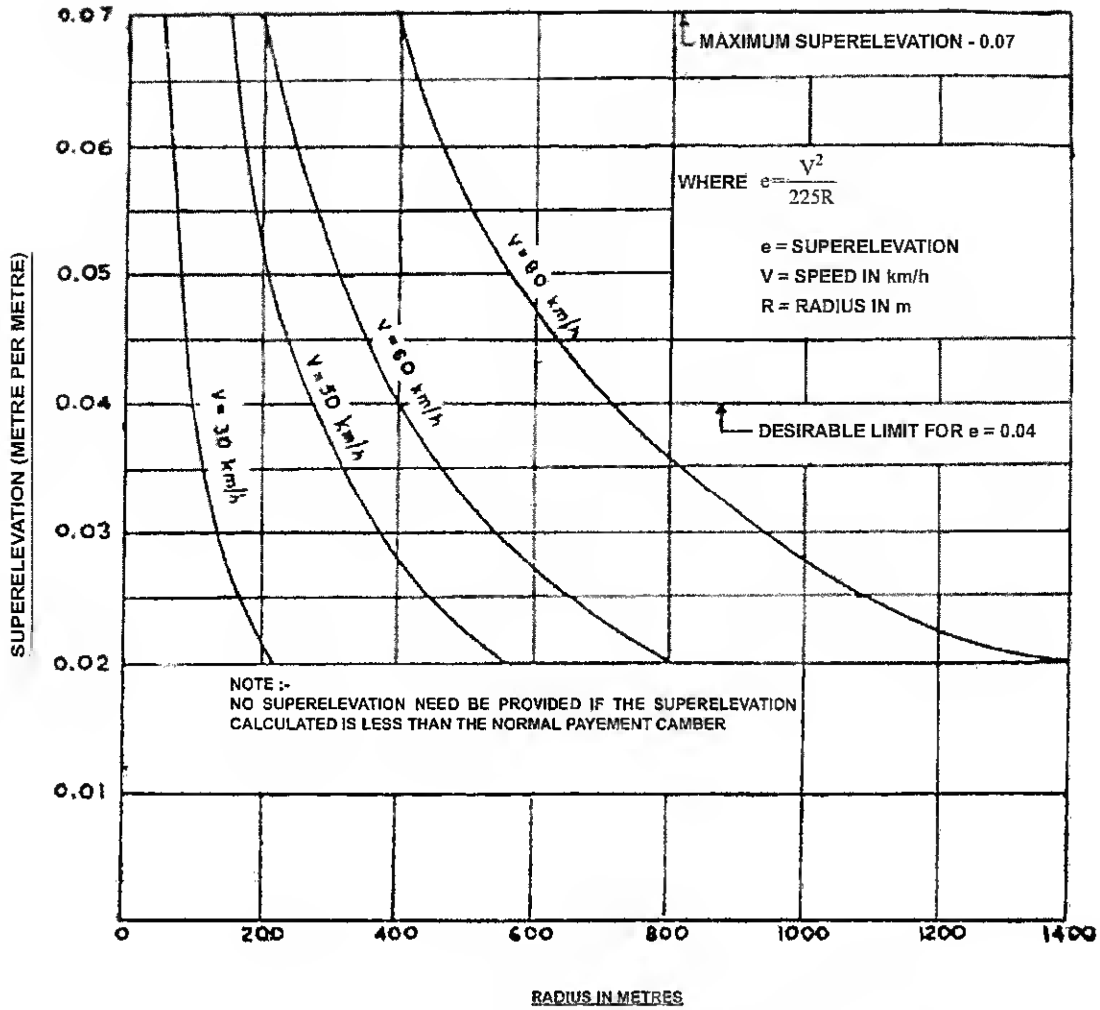


Fig. 8.3 Super Elevations for Various Design Speeds

8.2.2 *Radii beyond which no super elevation is required*

When the value of the super elevation obtained by using expression given in Section 8.2.1 is less than the road camber, the normal cambered section should be continued on the curved portion without providing any super elevation. **Table 8.1** gives the radii of horizontal curves for different camber rates beyond which super elevation is not required.

Table 8.1 Radii Beyond which Super Elevation is not Required

S.No.	Design Speed (km/h)	Radius (m) for Camber of		
		2.5 Per cent	2 Per cent	1.7 Per cent
1	20	70	90	100
2	30	160	200	240
3	40	280	350	420
4	50	450	550	650
5	60	640	800	940
6	70	870	1090	1280
7	80	1100	1400	1700

8.2.3 *Methods of attaining super elevation*

The normal cambered section of the road is changed into super elevated section in two stages. First stage is the removal of adverse camber in outer half of the pavement. In the second stage, super elevation is gradually built-up over the full width of the carriage way so that required super elevation is available at the beginning of the circular curve. There are three different methods for attaining the super elevation:

i) revolving pavement about the centre line;

ii) revolving pavement about the inner edge; and

iii) revolving pavement about the outer edge.

iv) **Annexure-II** illustrates these methods diagrammatically. The small cross-sections at the bottom of each diagram indicate the pavement cross-slope condition at different points.

Method (i) which involves least distortion of the pavement will be found suitable in most situations where there are no physical controls, and may be adopted in normal course.

Method (ii) is preferable where the lower edge profile is a major control, e.g. on account of drainage.

Where overall appearance is the criterion, method (iii) is preferable since the outer edge profile which is most noticeable to drivers is not distorted.

The super elevation should be attained gradually over the full length of the transition curve so that the design super elevation is available at the starting point of the circular portion. Sketches in **Annexure II** have been presented on this basis. Two-third super elevation may be attained on the straight section before start of the circular curve and the balance one-third on the curve.

In developing the required super elevation, it should be ensured that the longitudinal slope of the pavement edge compared to the centre line (i.e the rate of change of super elevation) is not steeper than 1 in 150.

When cross-drainage structures fall on a horizontal curve, their deck should be super elevated in the same manner as described above.

8.3 Minimum Curve Radius

Minimum radius of curve can be determined from the equation:

$$R = \frac{V^2}{127(e+f)}$$

where,

V	=	vehicle speeds in km/h
e	=	super elevation ratio in metre per metre
f	=	coefficient of side friction between vehicle tyres and pavement (taken as 0.15)
R	=	radius in metres

Based on this equation, minimum radii of horizontal curves for the different design speeds with maximum super elevation limited to 4 per cent and 7 per cent are given in **Table 8.2**.

Table 8.2 Minimum Radii of Horizontal Curves

S.No.	Design Speed (km/hr)	Minimum Radius (m) when Super Elevation is Limited to	
		7 Per cent	4 Per cent
1	20	15	20
2	30	30	40
3	40	60	70
4	50	90	105
5	60	130	150
6	70	175	200
7	80	230	265

8.4 Set-Back Distance at Horizontal Curves

Physical obstructions on the inside of horizontal curves often restrict sight distance. Sight areas on horizontal curves should be such as to provide driver with sight distance equal to the design stopping distance on curve. **Fig. 8.4** indicated the minimum width of set back from obstructions to sight measured from centre line of innermost lane. These values are applicable only when the length of arc of the curve is greater than the design stopping distance. For shorter lengths of curves, width of sight area should be checked by trial and error by assuming various positions of object and drivers on straight portions adjoining the curve.

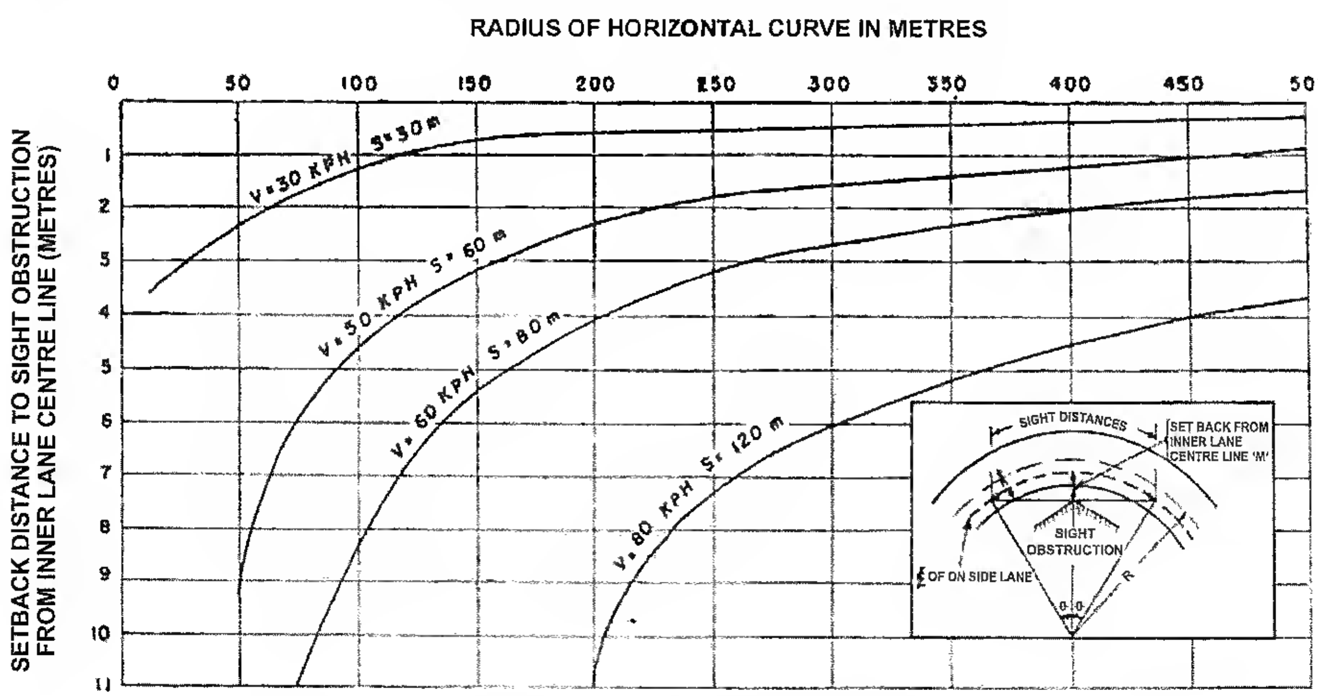


Fig. 8.4 Minimum Setback Distance Required at Horizontal Curves on Two Lane Urban Roads for Safe Stopping Distance

8.5 Transition Curves

Transition curves (See **Fig. 8.5**) are necessary for a vehicle to have smooth entry from a straight section into a circular curve. The transition curves also improve aesthetic appearance of the road besides permitting gradual application of the super elevation and extra widening of carriageway needed at the horizontal curves. Spiral curve should be used for this purpose. Minimum length of the transition curve should be determined from the following two considerations and the larger of the two values adopted for design:

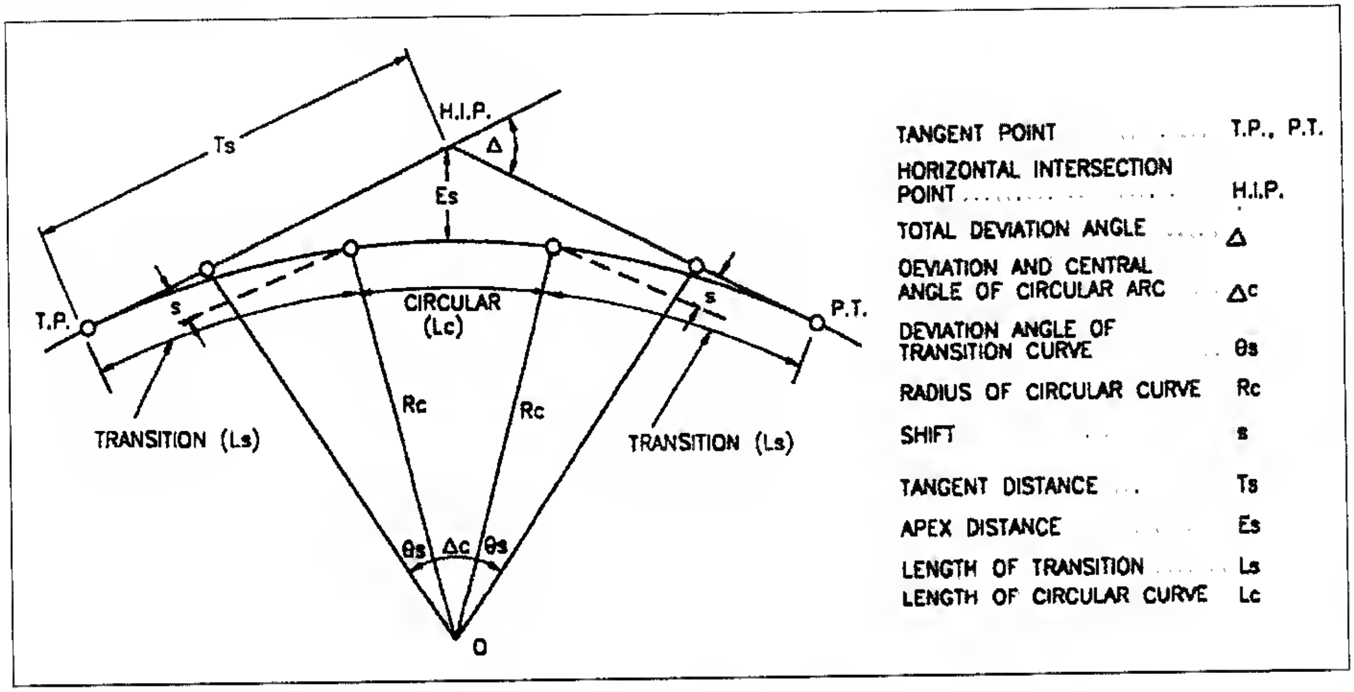


Fig. 8.5 Elements of a Combined Circular and Transition Curve

(i) The rate of change of centrifugal acceleration should not cause discomfort to drivers. From this consideration, the length of transition curve is given by:

$$L_s = \frac{0.0215V^2}{CR}$$

where L_s = length of transition in metres

V = speed in km/hr

R = radius of circular curve in metres

C = $\frac{80}{75+V}$

(ii) The rate of change of super elevation (i.e. the longitudinal grade developed at the pavement edge compared to through grade along the centre line) should be such as not to cause discomfort to travellers or to make the road appear unsightly. This rate of change should not be steeper than 1 in 150 for roads in plain and rolling terrain, and 1 in 60 in hilly terrain. The formula for minimum length of transition on this basis with super elevation limited to 7 per cent works out to:

For Plain and Rolling Terrain $L_s = \frac{2.7V^2}{R}$

For Hilly Terrain $L_s = \frac{1.0\, V^2}{R}$

Having regard to the above considerations, the minimum transition lengths for different speeds and curve radii are given in **Table 8.3**.

Table 8.3 Minimum Transition Lengths for Different Speeds and Curve Radii

Plain and Rolling Terrain							Curve Radius R (metre)	Hilly Terrain				
Curve Radius R (metre)	Speed (kmph)							Speed in kmph				
	30	40	50	60	70	80		20	30	40	50	60
15							15	30				
20							20	20				
25	NA						25	20	NA			
30	80						30	15	30	NA		
50	50	NA	NA				50	15	20	40	NA	NA
100	25	45	70	NA			100	NR	15	20	45	40
150	20	30	45	65			150		15	15	30	25
200	15	25	35	50	NA	NA	200		NR	15	20	20
250	NR	20	30	40	85	85	250			15	15	15
300		NR	25	35	75	75	300			NR	15	15
400			20	25	55	55	400				15	15
500			NR	20	45	45	500				NR	15
600				20	35	35	600					NR
800				NR	30	30	800					
1000					30	30	1000					

NA-Not applicable

NR-Transition not required

The elements of a combined circular and transition curves are illustrated in **Fig. 8.5**. For deriving values of the individual elements like shift, tangent distance, apex distance etc. and working out coordinates to lay the curves in the field, it is convenient to use curve tables. For this, reference may be made to IRC:38.

8.6 Widening of Carriageway on Curves

At sharp horizontal curves, it is necessary to widen the carriageway to provide for safe passage of vehicles. The widening required has two components: (i) mechanical widening to compensate for the extra width occupied by a vehicle on the curve due to tracking of the rear wheels, and (ii) psychological widening to permit easy crossing of vehicles since vehicles in a lane tend to wander more on a curve than on a straight reach.

On two-lane or wider roads, it is necessary that both the above components should be fully catered for so that the lateral clearance between vehicles on curves is maintained equal to the clearance available on straights. Position of single-lane roads however is somewhat different,

since during crossing manoeuvres outer wheels of vehicles have in any case to use the shoulders whether on the straight or on the curve. It is, therefore sufficient on single lane roads if only the mechanical component of widening is taken into account.

Based on the above considerations, the extra width of carriageway to be provided at horizontal curves on single and two-lane roads is given in **Table 8.4**. For multi-lane roads, the pavement widening may be calculated by adding half the widening for two-lane roads to each lane.

Table 8.4 Extra Width of Pavement at Horizontal Curves

S.No.	Carriageway Width	Radius of Curve (m)					
		Upto 20	21 to 40	41 to 60	61 to 100	101 to 300	Above 300
		Extra width (m)					
1	Two Lane	1.5	1.5	1.2	0.9	0.6	Nil
2	Single-Lane	0.9	0.6	0.6	Nil	Nil	Nil

The extra widening should be effected by increasing the width at an approximately uniform rate along the transition curve. The extra width should be continued over the full length of the circular curve. On curves having no transition, widening should be achieved in the same way as the super elevation i.e. two-third being attained on the straight section before start of the curve and one-third on the curve.

The extra widening should be applied equally on both sides of the carriage way. However the widening should be provided only on the inside when the curve is plain circular and has no transition. The extra widening may be attained by means of offsets radial to the centre line. It should be ensured that the pavement edge lines are smooth and there is no apparent kink.

9 VERTICAL ALIGNMENT

9.1 General

Vertical alignment in urban areas is governed by need to match building line and entrance line levels and levels of intersections and median openings.

9.2 Gradient

Most urban roads carry mixed traffic including slow moving vehicles like bicycles and animal/hand carts. Besides this, urban roads generally have intersections at frequent intervals. In view of this, as a general rule, a gradient of 4 per cent should be considered the maximum for urban roads. On roads carrying predominantly slow moving traffic, however, the gradient should desirably not exceed 2 per cent. At intersections, the road should be as near level as possible. As the urban roads are generally kerbed, a minimum gradient as indicated in **Table 9.1** for facilitating longitudinal drainage.

Table 9.1 Recommended Minimum Gradients

S.No.	Design Road Element	Gradient	
		Desirable Minimum (Per cent)	Absolute Minimum (Per cent)
1	Kerbed Pavements	0.5	0.3
2	Side Ditches (lined)	0.5	0.2

The desirable maximum gradients for pedestrian ramps and cycle tracks are also given in Section 5.3 and Section 5.6 of this manual:

9.3 Vertical Curves

Vertical curves should be provided at all grade changes exceeding those indicated in **Table 9.2**. The minimum lengths of vertical curves for satisfactory aberrance and maximum grade change without a vertical curve are given in **Table 9.2**.

Table 9.2 Minimum Length of Vertical Curves

S.No.	Design Speed (km/h)	Maximum Grade Change (Per cent) not Requiring a Vertical Curve	Minimum Length of Vertical Curve (m)
1	20	1.5	15
2	30	1.5	15
3	40	1.2	20
4	50	1.0	30
5	60	0.8	40
6	70	0.6	50
7	80	0.6	50

9.3.1 *Summit curves*

A curve with convexity upwards is called a summit curve. Summit curves in urban areas should be designed for safe stopping sight distance and they should be coordinated with horizontal curvature. Broken-back profiles should be avoided and wherever possible, approaches to bridges less than 30 m width should be designed to fit a single vertical curve.

Length of the summit curve should be calculated on the basis of the following formulae:

i) When the length of the curve exceeds the required sight distance i.e., L is greater than S

$$L = \frac{NS^2}{4.4}$$

where,

N = deviation angle, i.e., the algebraic difference between two grades

L = length of vertical curve in metres

S = sight distance in metres

ii) When the length of the curve is less than the required sight distance i.e., L is less than S

$$L = 2S - \frac{4.4}{N}$$

The minimum length of summit curves for stopping sight distance and various deviation angles have been calculated and given in **Fig. 9.1**. Summit curves shall be square parabolas($y = ax^2$) and minimum length should not be less than that given in **Table 9.2**.

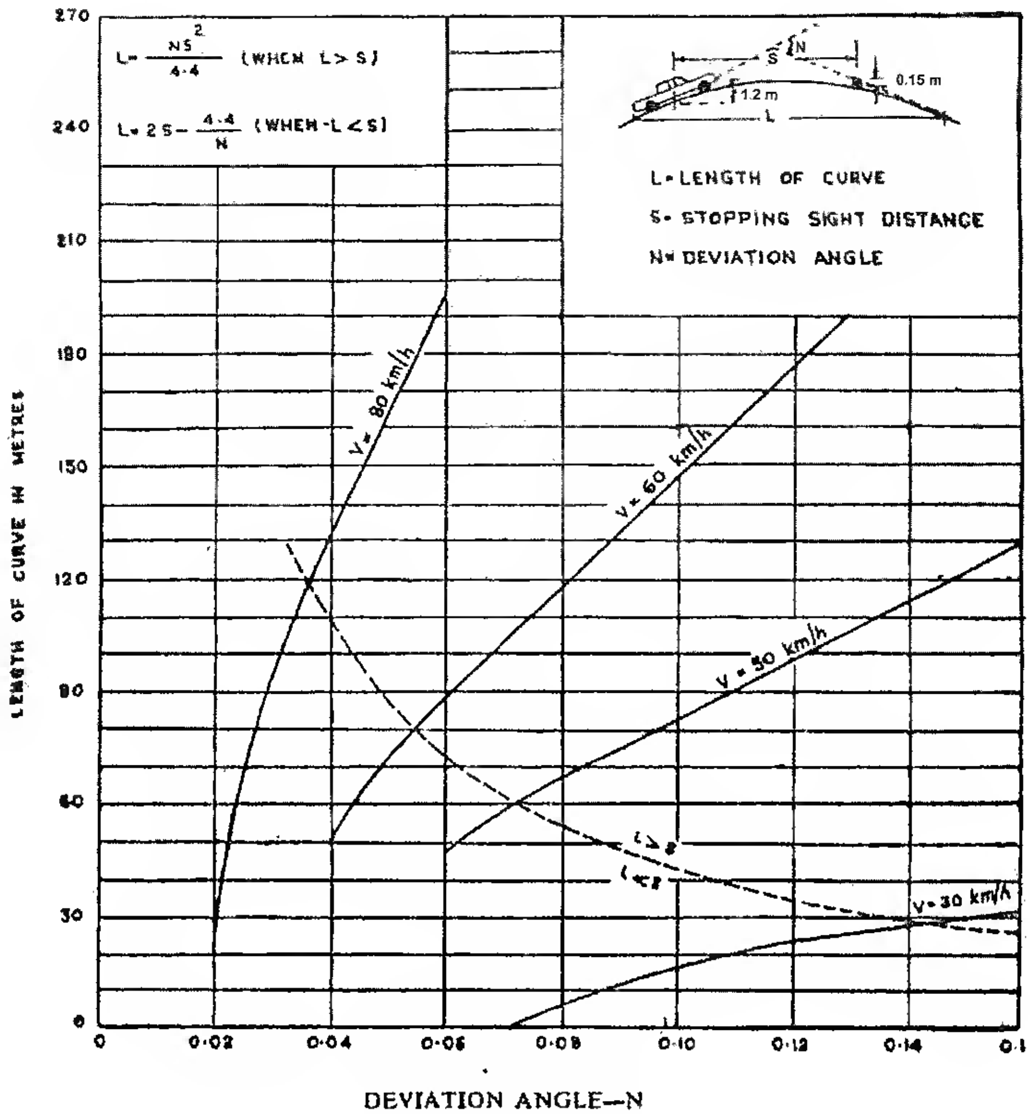


Fig. 9.1 Length of Summit Curve for Stopping Sight Distance

9.3.2 *Valley curves*

A vertical curve concave upwards is known as a valley curve, dip or sag. Valley curves on unlighted urban roads should be such that for night travel, the headlight beam distance is the same as the stopping sight distance. In accordance with this criterion, the length of the curve may be calculated as under:

i) When the length of the curve exceeds the sight distance

$$L = \frac{NS^2}{1.50 + 0.035S}$$

ii) When the length of the curve is less than the required sight distance

$$L = 2S - \frac{1.50 + 0.035S}{N}$$

The length of curves for various values of sight distance and deviation angles have been

calculated as per above formulae and given in **Fig. 9.2**.

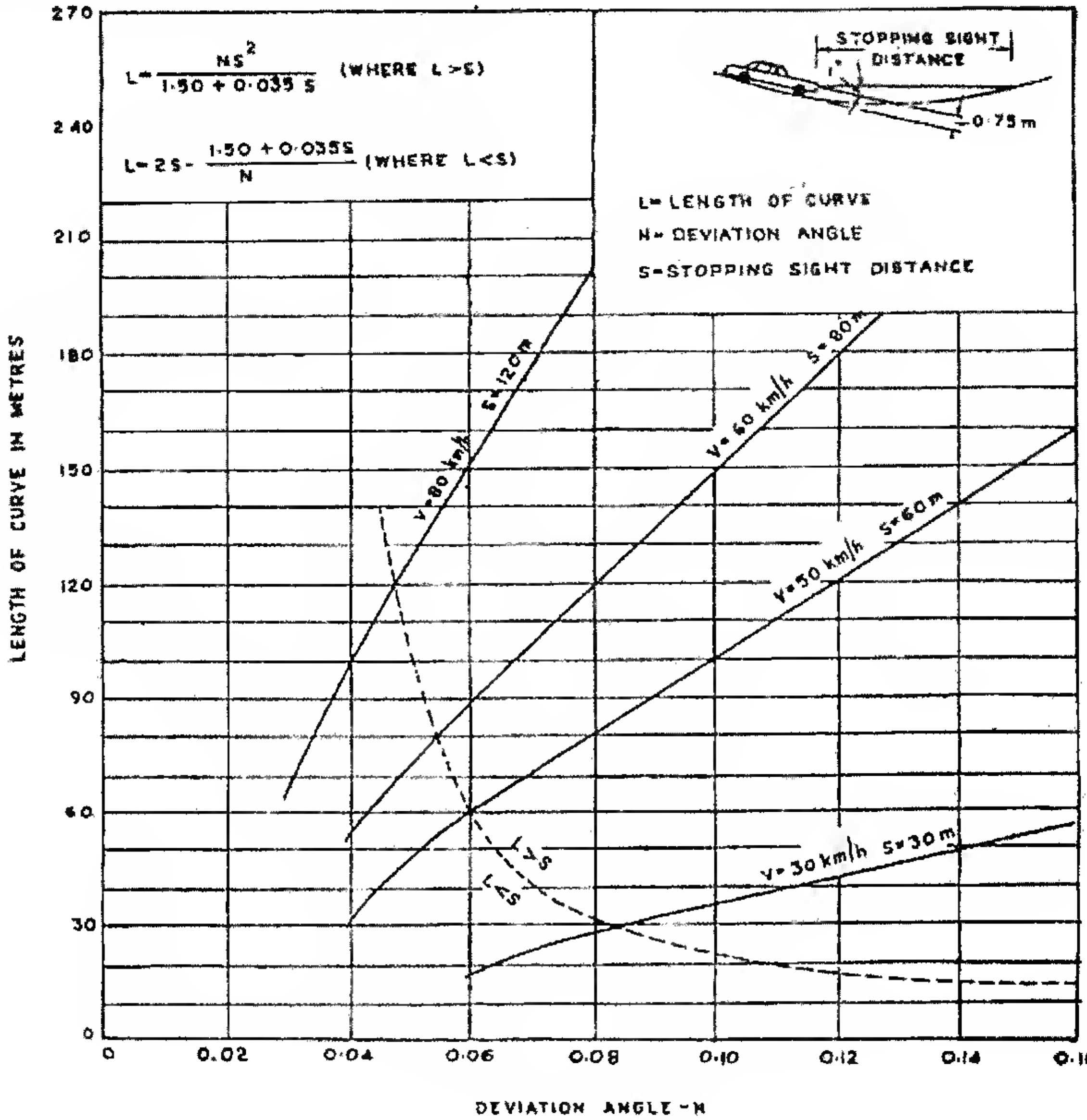


Fig. 9.2 Length of Valley Curve

Valley curves on urban roads which are usually lit during the hours of darkness may be designed merely for vertical acceleration of 0.5 g for riding comfort and in that case minimum lengths given in **Table 9.2** will suffice.

9.4 Co-ordination of Horizontal and Vertical Alignments

Horizontal and Vertical alignments should not be designed independently. They complement each other and poorly designed combination can mar the good points and aggravate the deficiencies of each. The design should be visualised in the perspective to achieve a flowing and pleasing view from the road. Following broad principles should be followed in alignment co-ordination:

i) The degrees of curvature should be in proper balance with the gradients. Straight alignment or flat horizontal curves at the expense of steep or long grades, or excessive curvature in a road with flat grades, do not constitute balanced designs

and should be avoided.

ii) Vertical curve superimposed upon horizontal curve gives a pleasing effect. As such the vertical and horizontal curves should coincide as far as possible and their lengths should be more or less equal. If this is difficult to achieve for any reason, the horizontal curve should be somewhat longer than the vertical curve.

iii) Sharp horizontal curves should be avoided at or near the apex of pronounced summit/sag vertical curves from safety considerations.

10 LATERAL AND VERTICAL CLEARANCES

Lateral and Vertical Clearances are required to be provided for overhanging loads and the tilting of vehicle towards obstruction by cross fall or super elevation of carriageway and for kerb shyness. Standards for lateral clearances for underpasses on urban roads are given in IRC:54. The same are recommended between edge of carriageway and obstruction on footpath, verge or central reserve. Where an obstruction is located on the inside of a bend, a greater clearance than that specified may be required to ensure that the sight distance is not less than the minimum.

10.1 Underpass for Vehicles

Lateral Clearance: The lateral clearance from the edge of pavement should be as follows:

a) Pavement without footpath

Minimum clearance from the edge of pavement

- Arterial and sub-arterial road : 1.0 m
- Collector and local streets: 0.5 m

b) Pavement with footpath

- No extra clearance beyond the footpath is necessary.

c) Clearance on divided carriageway

The left side clearances should be as above. The right side clearance to the face of any structure in the central median shall be as follows:

- Arterial and sub arterial road: 1 m from the edge of pavement
- Collector and local streets: 0.5 m from the edge of pavement

Vertical Clearance: The minimum vertical clearance on urban roads should be 5.5 m.

11 DESIGN OF PUBLIC UTILITIES

Careful location and planning of physical infrastructure services and urban utilities is critical in order to allow easy access for regular repair and maintenance of utilities, while causing minimum disruption or disturbance to other street users. For details refer IRC manual on Planning and Development of Urban Roads and Streets.

12 TOPOGRAPHICAL DATA

Following topographical surveys are recommended for collection of topographical data for urban roads to improve the existing road/street geometry elements or to propose new infrastructure

facilities:

Stereo Satellite Data: Stereo Satellite Imagery is a form of Stereoscopy or 3D image. Stereo image pairs are used to make Digital Elevation Models (DEMs) and Digital Surface Models (DSM).,Stereo satellite data can be procured through National Remote Sensing Center (NRSC) of Indian Space Research Organisation (ISRO).

Total Station Survey Data: Total Station (TS) is an all in one instrument fulfilling the needs of a theodolite, a levelling instrument and a DISTOMAT (Electronic Distance Measurement Instrument).TS also has an inbuilt software which makes all the necessary computations. Microprocessor in TS will support software to perform various mathematical operations such as multiple angle and distance measurements, horizontal and vertical distances, and corrections for atmospheric and instrumental corrections. The detachable data cards and data transferring equipments support to transfer the data. Using TS and mapping Software, the maps can be created automatically.

LiDAR Data: Light Distance And Ranging (LiDAR) is a technology for measuring the positions of physical objects rapidly. LiDAR uses a laser beam to measure the distance from an object to the scanner, and mechanical-optical mount to scan the laser across a scene accurately. LiDAR is useful not only because it can provide accurate positions over large areas, but also because it is fast, LiDAR can collect tens of thousands to over a million positions per second. Collecting location based data at this level of detail through traditional surveying would take more time.

LiDAR data can be collected from airborne or terrestrial vehicles, from fixed positions, usually on a tripod, and offshore platforms. In terrestrial acquisition, the LiDAR unit is mounted either on a tripod or on a vehicle. With terrestrial mobile systems, a coupled GPS-IMU solution is needed to track the device position during data acquisition. Ground control GPS locations are also used with mobile systems both for calibration and quality assessment. With tripod mounted systems, GPS control can be either from a GPS on the unit, plus one or more control points on the ground to provide geometry, or from multiple GPS targets on the ground.

Unmanned Aerial Vehicle Survey (UAV) Data: An Unmanned Aerial Vehicle (UAV), commonly known as a drone, as an unmanned aircraft system or by several other names, is an aircraft without a human pilot aboard. The flight of UAVs may operate with various degrees of autonomy either under remote control by a human operator, or fully or intermittently autonomously, by onboard computers.

13 GEOMETRIC DESIGN SOFTWARE

Most public agencies and consulting firms engaged in a large volume of design work now employ computer software to assist in the design of transportation facilities. Such design packages are used in conjunction with Computer-Aided Drawing (CAD) software to produce facility plans that include horizontal and vertical alignments. The most common arrangement is for the design and drawing programs to run simultaneously, with the design program calling routines from the drawing program as needed to construct the drawings. It is also possible to have the design and drawing programs communicate by exchanging graphic files. The process of designing a transportation facility with a design software package usually begins with a Digital Terrain

Model (DTM) obtained from topographical survey data. If a DTM is available, this may be used to construct a contour map. The slope aspect map to be used as a base map for design of geometric elements. Other features, such as existing structures, may be added to the base map by means of the drawing program.

Once the base map is completed, the user begins to design the facility by defining horizontal and vertical alignments. The horizontal alignment will be defined first; based on this; the design program will display existing elevations along the center line or other primary reference line. A single project may have multiple alignments; for instance, divided roadways with wide medians can be designed with separate horizontal and vertical alignments, and separate ditch profiles may be specified. In constructing alignments including horizontal and vertical, critical points such as Point of Intersections (PI) may be established either by specifying coordinates or (in the case of vertical alignment) stations and elevations, by projecting known directions or grades and distances from existing points, or visually, by dragging the point with a mouse or other digitizing device.

The design software usually provide for automatic stationing of alignments and fitting of standard features such as circular horizontal curves, spirals,and parabolic vertical curves. The user also defines templates, describing the facility cross section. These define the geometric cross section, ditch shapes, and earthwork cross-slopes.

The design program has the capability of calculating transitions between successive templates in the case of multiple templates. Where there are super elevated curves, the user enters the location and other details of super elevation transitions, and the program modifies the cross-section templates to account for the super elevation.

Once alignments and templates are defined, the program constructs a single three-dimensional mathematical representation of the facility from them. This can be used to produce three-dimensional views. These may be rotated and zoomed to produce three-dimensional drawings of the facility from any point of view. Also, once alignments and templates are established, the program calculates earthwork cross sections by means of a digital terrain model of base model and design model. Once earthwork cross sections are established, the design program can calculate earthwork volumes.

Advantages of using software packages to design transportation facilities include:

- Design software provides for rapid design, redesign of facilities; in particular, earthwork quantities for new alignments may be calculated very rapidly. This is a major advantage, since manual calculation of earthwork quantities is a laborious process.
- Design software provides the ability to easily visualize facilities in three dimensions. Because three-dimensional representations may be constructed from any viewpoint and on any orientation, it is easy to evaluate the appearance of the facility.
- With the design and drawing software, drawings may be re scaled rapidly, and multiple versions of drawings emphasizing different features may be readily produced. Drawing programs allow graphical objects to be grouped into different layers.

REFERENCES

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2. IRC:103-2012 "Guidelines for Pedestrian Facilities", Indian Roads Congress, New Delhi.
3. IRC:69-1977 "Space Standard for Roads in Urban Areas", Indian Roads Congress, New Delhi.
4. IRC:73-1980 "Geometric Design Standards for Rural (Non Urban) Highways", Indian Roads Congress, New Delhi.
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6. IRC:SP:23-1983 "Vertical Curves for Highways", Indian Roads Congress, New Delhi.
7. IRC:SP:99-2013 "Manual of Specifications and Standards for Expressways", Indian Roads Congress, New Delhi.
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10. IUT Code of Practice Part-1 Design of Urban Roads-Code of Practice, Ministry of Housing and Urban Affairs, Government of India.
11. Non Motorised Transport Planning and Design Guidelines.
12. TRIPP, Source:http://tripp.iitd.ernet.in/publications/other_pub/Planning%20and%20Design%20Guideline%20for%20Cycle%20Infrastructure.pdf

Annexure-I

Guidelines for Grade-Separated Pedestrian and Cycling Facilities

Foot-over bridges and subways increase the walking distance for a pedestrian/commuter, which is inconvenient and therefore discouraged to the extent. The following design guidelines shall be adhered to:

- Foot over bridges and subways shall have universally accessible ramps (gradient 1:20 with landing at adequate intervals), lifts and steps (landings at appropriate levels) can be provided.
- Escalators are not an inclusive measure. Introduction of such facilities would lead to a compromised arrangement of NMV and pedestrian track leading to sub optimal conditions if there is a restricted ROW.
- A slope of 5% (1 in 20) on footbridge ramps with appropriate resting places/ landings is preferable.
- Within the subway, a handrail set 760 mm-900 mm above the walking surface should be provided along with adequate natural light and ventilation.
- To assist visually impaired people, tactile paving/ tiles and a colour contrast should be provided at the top and bottom of the flight of steps and these areas should be well lit.
- Ramp/lift is mandatory and steps/escalators can be provided. Lifts should be on both the entrances/exits and should have minimum internal dimensions of 1500 mm x 1500 mm.
- Greater safety can be achieved by having hawker spaces in some subways and/or video surveillance camera. This grade separated alternative is of least priority.
- Pedestrian and Cycle subway should be minimum 2.5 m (width) x 2.75 m (clear height).
- Combined cycle and pedestrian subway should be minimum 5 m wide for one-way traffic and 6.5 m wide for two-way traffic. The minimum height should be 2.75 m.

Case 1: Access to a sheltered overhead pedestrian bridge with steps

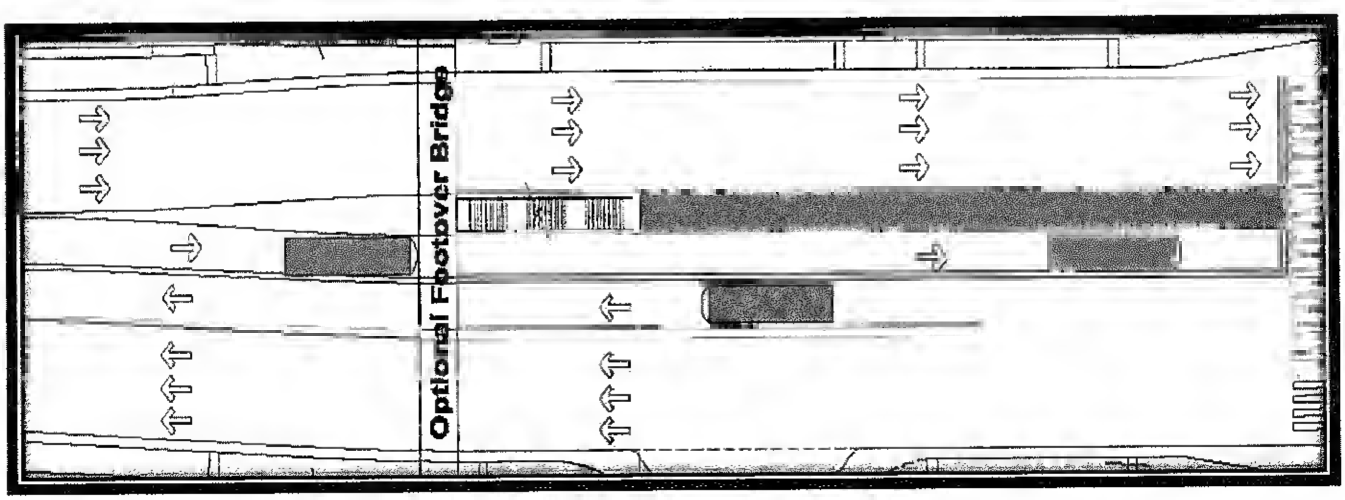


Fig. 1 Access to a Sheltered Overhead Pedestrian Bridge with Steps

Case 2: Access to the shelters via step

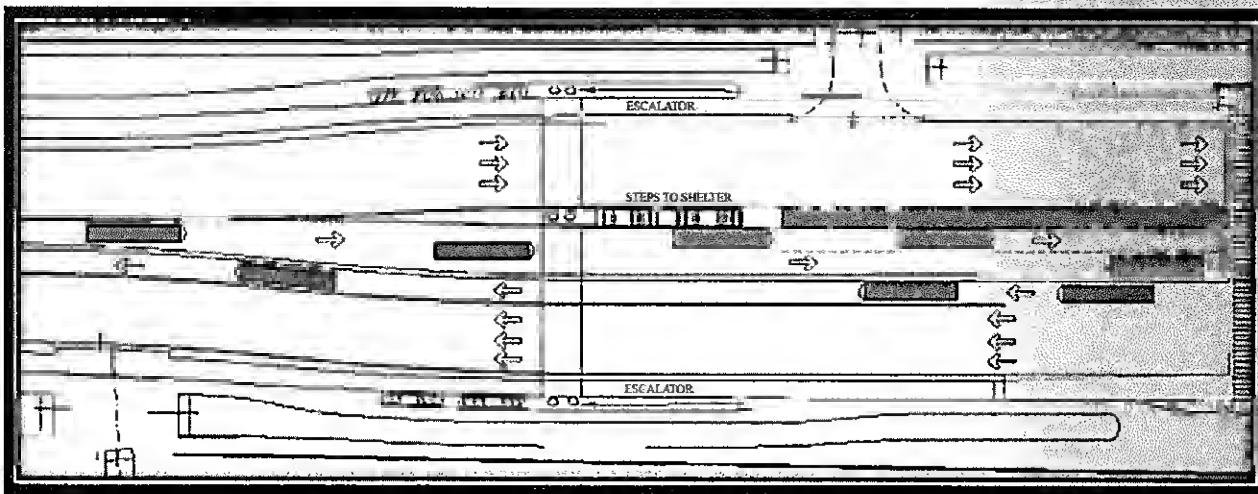


Fig. 2 Access to a Sheltered Overhead Pedestrian Bridge with Steps and Escalator

Case 3: Access to the shelters via steps and escalators and lifts

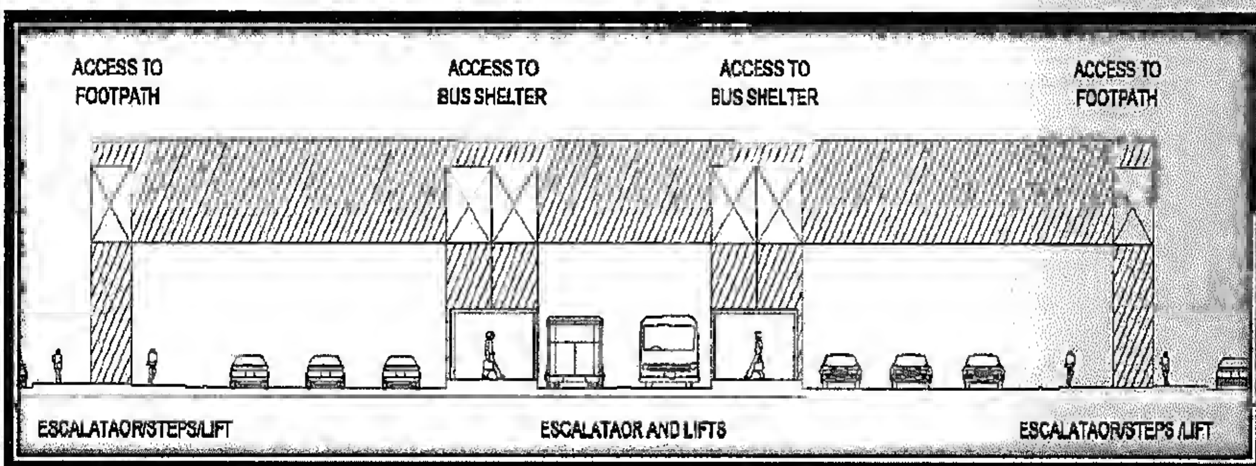


Fig. 3 Access to the Shelter – Overhead Bridge with Steps and Escalator and Lifts

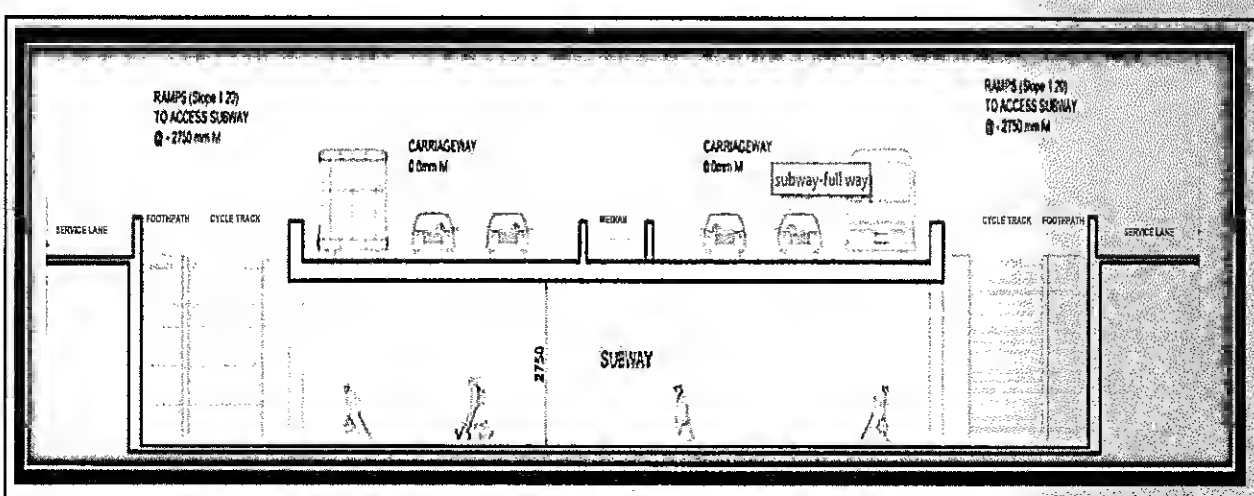
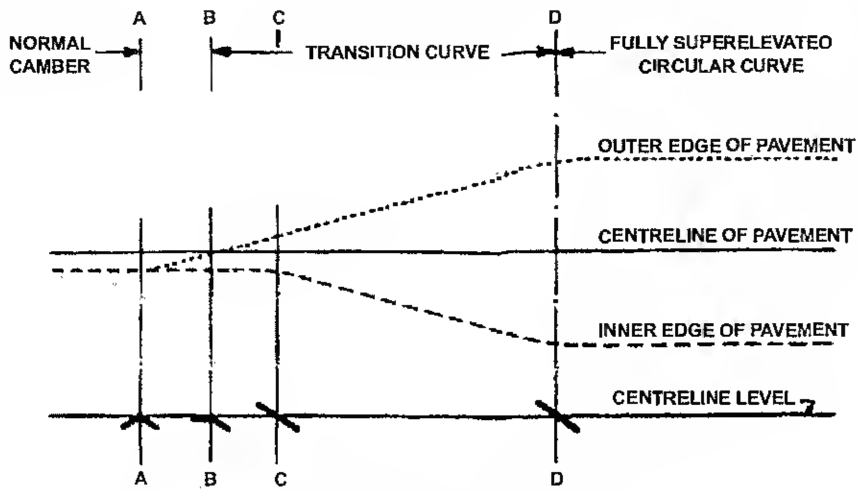


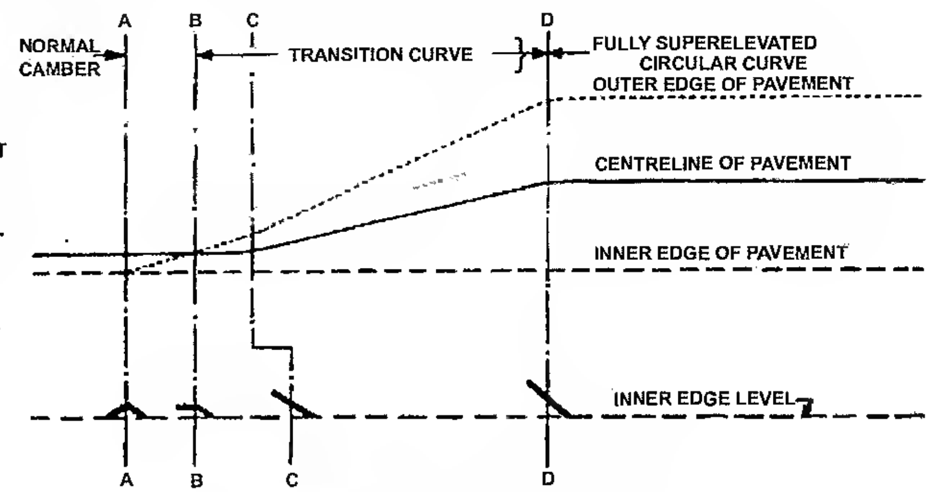
Fig. 4 Full Subway

Annexure-II

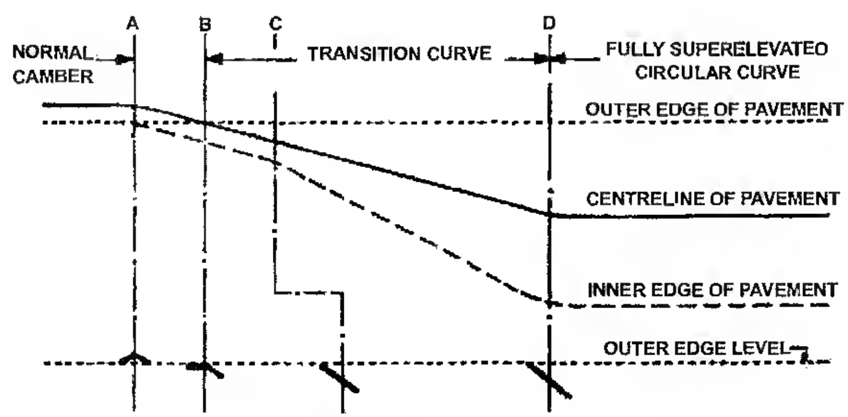
Schematic Diagram Showing Different Methods of Attaining Super Elevation



(a) PAVEMENT REVOLVED ABOUT CENTRELINE



(b) PAVEMENT REVOLVED ABOUT INNER EDGE



(c) PAVEMENT REVOLVEO ABOUT OUTER EOGE

LEGENO

CRDSS SECTIDN AT AA – NDRMAL CAMBER

CROSS SECTION AT BB – ADVERSE CAMBER REMOVED

CROSS SECTION AT CC – SUPERELEVATION EQUAL TO CAMBER

CRDSS SECTION AT DD – FULL SUPERELEVATION ACHIEVED

NOTE :–

THE RATE OF CHANGE OF SUPERELEVATIDN (LONGITUDINAL SLOPE OF EDGE COMPARED TO CENTRELINE) SHDULD BE MINIMUM 1 IN 150 FOR ROADS IN PLAIN AND ROLLING TERRAIN AND 1 IN 60 IN MDUNTAINOUS AND STEEP TERRAIN THE ACTUAL RATE USED WILL DETERMINE THE DISTANCES AB, BC AND CD